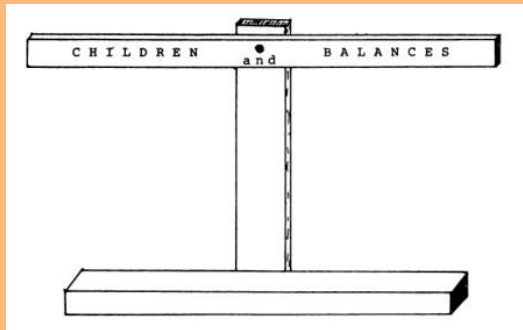
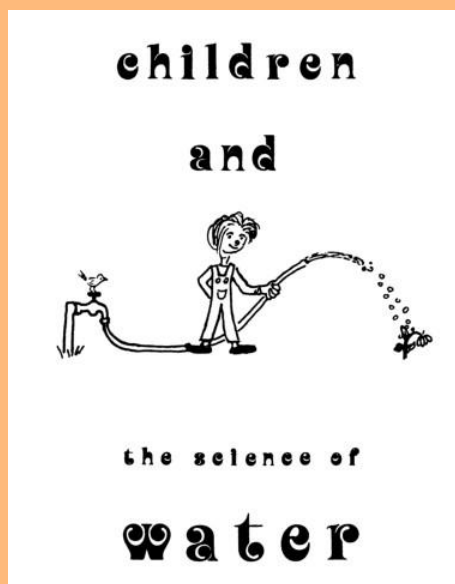
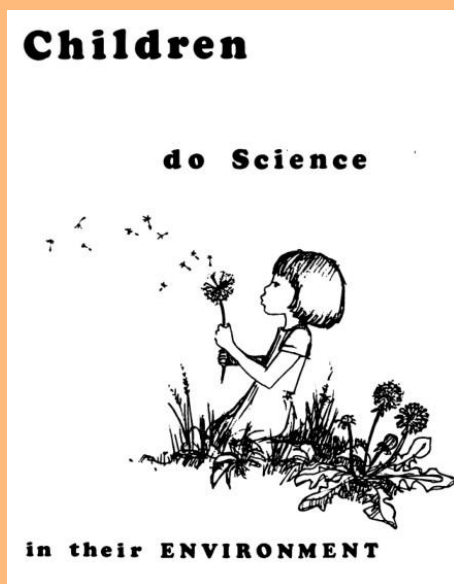


ENGAGING CHILDREN IN ACTIVE SCIENCE

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PART TWO

Engaging children in active science

Jos Elstgeest

Classroom activities and teacher education

Introduction

The next four chapters of this book comprise suggestions for activities which exemplify the approach to teaching and learning which we have attempted to describe and explain in Part One. Each chapter's activities concern a particular topic:

- children and water;
- children and their environment;
- children and reflections; and
- children and balances.

Of course these do not cover all the areas of content with which primary science is concerned (as proposed in Chapter 1, for example) but the purpose here is not to provide a comprehensive guide to classroom work but rather to exemplify in specific terms the things which children should do to help their learning. The presentation of the activities is also designed to indicate an effective way of encouraging children to engage in this doing. The four topics have been chosen because:

- they cover a good deal of the core ideas;
- they are of interest to children everywhere and can be applied in almost any conditions in any place in the world; and
- they require only simple and readily available materials.

The activities within the four topics have been used with children and with teachers in training and they illustrate:

- how ideas and information can be gained by active inquiry, by 'asking the water, or . . . the balance, or . . . the mirror, etc.';
- how process skills are used in this active inquiry; and
- how inquiry leads to more questions and more investigations, which in turn advance ideas and skills, which lead on . . . and on . . . to more learning.

The activities in Chapters 14 to 17 have a dual purpose: in the classroom and in the context of teacher education. In this brief introductory chapter we consider their use in teacher education and point out some of the issues of practical teaching that are best addressed in the context of actual classroom activities, for example, the use of worksheets, the identification of opportunities for developing certain process skills and the recognition of what anyone engaged on scientific activity is doing, are most usefully discussed in terms of specific examples.

What we are suggesting is that teachers and student teachers should work through many of the same activities as proposed for children, for reasons which go far beyond trying things out 'to see that they work'. We now consider the four most important of these reasons to be:

- helping the understanding of the nature of scientific activity;
- helping the understanding of how children's learning can be assisted;
- developing a deeper personal knowledge of science; and
- developing ability to criticize, adapt, extend and create further activities for children.

Such is the potential for learning in everyday things around us that the same activities which provide for young children to make steps in their learning also provide an opportunity for students and teachers to develop their ideas at a much more advanced level.

UNDERSTANDING OF THE NATURE OF SCIENTIFIC ACTIVITY

In Chapter 1 we described the process of learning as being much the same for adults as for children. There are differences in the components of the process, of course. The experiences of adults are much wider than those of children, the ideas they bring to bear in understanding new experiences are more abstract and generalized and they also have the ability to stand back and reflect upon the process of their learning. The important similarity lies in the way existing ideas and new experiences lead to the development of ideas and in how understanding results from working things out from one's own experience.

In order for teachers to be able to provide fruitful learning experiences in science for their pupils, they must recognize the nature of scientific activity. This is not easy to describe in theory, but it is easy to recognize in action. Many primary-school teachers will not have had experience of this in their own education and this must be made good in their preparation for teaching. Doing some science at their own level can start, however, from simple activities such as can be undertaken by young children. The activities with the balance (Chapter 17) provide a good example. The first few pages of the activities invite children just to play with their balance and, whilst it is not proposed that

student teachers go through these elementary steps, they may well begin by investigating how the balance can be brought into equilibrium by putting different things on each side. The more precise observations which can be made using the peg-board balance (page 266) lead to the identification of relationships. Before long students or teachers are busy suggesting relationships, using them to say what should put the balance in equilibrium and testing them out. Whether or not they formulate the relationship in the formal way is unimportant. What is important is that they have found something out from the materials in front of them by manipulating, by doing and by thinking.

It is important for there to be experience of scientific activity in various contexts (as, for example, in Chapter 2 as well as the topics in Chapters 14 to 17), particularly for those who have had little experience of learning this way themselves. When they have been through these experiences, then they can stand back and examine them, and understand what makes these *scientific* activities. The experience of scientific activity is not enough; teachers must know that this is what they experienced.

UNDERSTANDING HOW TO HELP CHILDREN LEARN

The personal experience by teachers of activities which children will be undertaking can be the basis for discussing how children may tackle them and what they may derive from them. The advantages and disadvantages of particular activities can be considered in these terms. This is only possible if teachers and trainees have undertaken the same activities, including the thinking and reasoning, the searching for evidence and the making of conclusions on the basis of the evidence found.

Through their personal experience of the ideas and skills involved, they can discuss what children at different points in development will need in terms of support and encouragement from their teacher. Reflecting on how they felt themselves as learners will prepare them for what a teacher needs to do to translate activities from a page into lively learning opportunities for real children.

A DEEPER PERSONAL KNOWLEDGE OF SCIENCE

The simple activities with water in Chapter 14 exemplify how understanding can be developed at different levels. This is helpful because it satisfies the adult learner to go beyond the simple explanation which is appropriate for young children. More than this, though, it shows teachers that there is no end to the sophisticated and complex answers to the question 'why' in science and so the worry about not being able to give children the 'correct' explanation should be dispelled. What is 'right' for children is what they can understand in the light of their past experience and the evidence before them. As this expe-

rience grows and new evidence emerges, then more advanced ideas are needed and understood.

A simple activity with water, such as 'floating and sinking', carried out by teachers, may go beyond identifying things that float and sink to noticing that some things which sink can be made to float if they are placed on the surface with care. A needle or a paperclip can be made to lie on the water surface and careful observation reveals that these objects appear to make a depression in the surface of the water. An object floating in the normal way, however, such as a cork, appears to draw water up where it touches, rather than depressing it. Suggestions for comparing these things are given on page 169. The explanation for these observations in terms of surface tension may well satisfy children.

But why should water behave in this way? To go beyond the descriptive explanation requires understanding of the molecular nature of matter and the forces between molecules. This is a good opportunity for teachers to extend their knowledge of the way in which the macroscopic properties of materials are explained in terms of their sub-microscopic constituents and it may help them to explain a whole range of other phenomena. There is still another 'why', however, about why the molecules behave as they do, and we have to go into sub-atomic structure for this explanation. Recognizing that this is a stage of explanation which they are not going to understand is useful to teachers in putting them in the position of children who may be force-fed an explanation which is beyond them. Knowing where to stop in giving explanations and information is important knowledge for the teacher!

At this point it may be useful to underline certain points about what is often termed 'the necessary background knowledge' of primary-school teachers. It would be quite wrong to give the impression that this consists only of scientific knowledge. Such knowledge is necessary and desirable, to a point beyond the level of the children being taught, and it is best obtained through extension of practical activities of the kind described in the following chapters. But it is not sufficient in itself. The necessary knowledge for teachers extends to knowledge of how children learn in general and how they learn science in particular. It must include how to bring about this learning and how each activity makes its contribution to it. Intimate familiarity with the activities through carrying them out and evaluating them for themselves and then through the work of children is part of the essential and developing knowledge base of teachers.

ABILITY TO ADAPT, AMEND AND EXTEND ACTIVITIES

The introductory remarks to the activities in Chapters 14 to 17 emphasize that the activities do not form and are not intended to be used as a ready-made programme. Teachers are expected to use them to make up their work pro-

grammes since no one can do this from a distance. Whilst the general objectives of science education are the same, the details of the curriculum vary from country to country and place to place within a country. To use the suggestions here (or from other sources, for that matter) it will be necessary for teachers to accept the responsibility for adapting them to suit the circumstances of the class, the school, the locality and any national syllabus. The activities in the chapters give a helping hand but do not remove opportunities for teachers to use creative initiative.

To develop the ability to use materials in this way, it is first necessary for teachers or student teachers to carry out the activities. Then their tutor should help them to stand away from the materials and consider them critically. Some of the criteria suggested in Chapter 12 (page 145) might be introduced to consider a unit of work as a whole. It is at the level of individual activities, however, that changes have to be made and where new ideas may come up for extending activities. During activities with water drops, for example, some students realized, for the first time, how drops of water magnify. They were off to find out how much a particular drop magnifies, how this magnifying power can be increased, how the drop can be conveniently held steady so that it is a useful magnifier. Then they turned their attention to using these ideas with children, both in following similar lines of inquiry to their own and in using the product as a magnifying glass.

Trying out activities also brings insight into the effectiveness of the suggested materials. Often improvements can be suggested or substitutions made, where proposed materials are not available. A large part of the discussion in teacher education should centre around the development and application of available materials and equipment, and their appropriateness and effectiveness. If this is done from a base of trial and experience it should do much to prevent teachers' being deterred from providing practical science for their pupils on account of lack of the exact materials which are suggested.

The use of worksheets

A final general comment about the use of worksheets is in order here since the activities in Chapters 14 to 17 are presented in this form. It is suggested in some instances that certain pages can be copied for use by children. However, in general their intention is to be exemplary only and in practice altered, enriched, extended and even replaced. Teachers learn how to make these changes in workshops. So it is important to include in teacher education an opportunity for teachers to 'do' worksheets. This is fine and fun at first; it often opens up possibilities not thought of. But for an adult the worksheets provide little challenge in terms of their content. The challenge for teachers in work-

shops is not so much the 'doing' but in analysing what makes a good worksheet and trying to make some. Students and teachers can sharpen their skills by making worksheets for each other. When they try each others' there is a built-in evaluation.

The discussion should bring out the pros and cons of worksheets and establish criteria for a good worksheet. Some of the following points may be included in the discussion.

Pros: Worksheets are handy and help children to work independently so that the teacher is free to pay attention to other things.

Cons: How independently are the children working if they depend on a worksheet? Does the worksheet really leave room for the children's own thinking?

Problems: When children are at a loss as to what to do next after they have 'finished' their worksheet, is this not a cause for concern? Should a worksheet not end with a further suggestion, a new question, or with reference to some reading? How can we create an 'open end' so that children continue investigating and exploring?

Wording: Does the wording on the worksheet present a problem in understanding? Is it made clear when an instruction should be followed strictly or when it is just a suggestion, leaving room for children to show initiative?

Content: Are the problems proposed real ones? Will they engage the children? Are there closed questions which really need no extended investigation – such as 'Do letters change in the mirror?' or 'Can you see the things behind you in the mirror?' Such questions discourage thought and turn a worksheet into a guessing game.

After considering the negative aspects, however, it is important for teachers to take a positive view. A good worksheet is not an impossibility. It poses questions in open form and not always in words. It makes clear what kinds of equipment can be used and specifies what is essential and what is optional. It gives information which may be useful but does not inhibit activity. It leads to other investigations, in various ways, perhaps by referring to another worksheet or to what children might do to extend the inquiries. It is attractive to the age-group of children for which it is intended and it provides an invitation to 'ask the . . .' to give answers to children's questions.

Children and water

Introduction

Water is a common yet exciting material, freely available almost everywhere, which lends itself to an endless variety of genuine science activities. Common as it appears to be, water can be a source of wonder to children and to adults who have kept up the habit of questioning and wondering. Waterplay is one of the earliest forms of children's exploration. At normal temperatures water is pleasant to work with. Some of its properties are easily revealed and these early experiences are the start of more detailed and sophisticated ideas. 'Water makes things wet' is one of those early experiences, but that this high adhesive power is due to its molecular structure giving it a strong negative polarity is an idea which requires many more experiences and related ideas formed by reflection and thought.

All investigations of water at primary-school level can be carried out with the simplest of materials, readily available or made or improvised. Providing materials for the study of water is by itself an inviting challenge. For example, a zig-zag gutter system of split bamboo stalks or banana leaf stalks to convey water from one place to another was initiated by a practising student-teacher and carried out by a class of children in order to solve the problem: 'How can we make it easier to water our garden from the well above?' This chapter indicates many simple materials which can be used for qualitative as well as for quantitative work. Most of the things demand only the effort of collecting them. Some, however, require more careful, though simple, fashioning; for instance the making of little wooden floats of different shape, but of the same area (page 174), or the waxed cardboard shapes made to test surface tension (page 190).

Within this chapter are various activities comprising a certain sequence of experiences which are related to a particular aspect of the science of water. An

example of this is 'surface tension'. This phenomenon is introduced as a first experience on pages 169 and 170, where the surface tension makes a meniscus and supports a 'floating' paperclip. Little, if any, explanation of the phenomenon itself is required here. At best this may be a good time to introduce the proper term 'surface tension', but it will only stand for a still hazy concept. The concept, however, may well gain in sharpness when children have been 'heaping drops' (page 176), when they have experienced the problem of 'how full is full?' (page 177) and have measured its 'strength' with a balance (pages 189 and 190), Constant referring to and from – to previous experiences from present ones – consolidates the idea, and helps to test whatever new notion arises from fresh experience, such as the adhesive property of water resulting in the phenomenon of capillarity and 'soaking up' (pages 185–8). By the time children have undergone and discussed various experiences of surface tension, their concept may be rich enough to make a relation between their observations, so that they can begin to seek for, and discover, a satisfactory explanation, even though it remains incomplete at this stage.

The actual sequence of activities related to surface tension is rather arbitrary, of course, but every fresh experience provides a new angle or a different point of view which is a step forward towards a better understanding of this property of water. The explanation of it in terms of the electro-magnetic forces prevailing in the lopsided structure of the water molecule will still be well beyond the grasp of children (and most teachers). But if they do recognize relationships between their observations and the outcomes of their 'what happens if . . .' experiments, they will begin to construct a pattern which gives momentary satisfaction, which is correct though inconclusive and which leaves the search open for further hypothesis and investigation. Those who later continue the quest for deeper understanding will find that the mental ground has been well prepared to foster further insight.

This chapter on the science of water brings out another important aspect of scientific activity: the recognition, use and control of variables. This ability is rather difficult to 'teach', as it requires some insight and hindsight into one's own investigative work which makes critical appraisal possible.

A first acquaintance with variability is presented on page 169. Objects of various shapes and materials float on water in a different way: some deep in the water, others high up; some fall on their side, others stay straight up. Children are asked to observe and describe these variations. So far the children are only asked to make observations, but the observations include the different properties of the objects they use, as well as the consequent difference in behaviour while floating. Something similar is called for when they compare how different shapes of wooden floats of the same area can hold different loads (page 174).

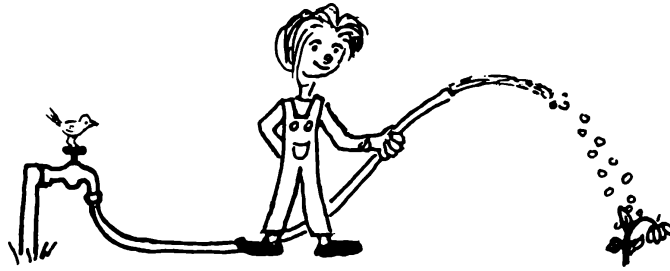
The idea of varying shape and size in turn is not included in the activity

yet. Some intuitive agreement that the area should remain the same while the shape may vary is all that is suggested.

On page 176 a further step is taken when children start 'heaping drops' of various liquids onto various substances. Although 'heaping drops' basically asks for 'what happens if . . .' observations, these variables become important when results are to be compared. What can be varied are the liquid, the surface on which it is dropped and the number of drops. The results are to be found in the shape and size of the drops as they lie on the surface material. Children can see, and sometimes even measure, differences in diameter and vertical height, and they can compare the curvature of the surface of the drops. This is about as far as one can go with primary-school children: good observation and accurate recording. Nevertheless, part of the accurate recording is the mentioning of the variables: the liquid, the surface and the number of drops. Now they can establish certain facts on the basis of evidence collected. The fact that different liquids have different 'heaping' properties and the fact that different surface materials interact differently with water, spirit or whatever other liquid, are probably all that the children can conclude at this stage. But that is sufficient.

In connection with the experiments on capillarity where the 'natural flow' of water appears to be reversed, the need to *control* variables can be made obvious. This is a good opportunity to pay special attention to it, to point out once more what variables are, how this idea applies to these situations and how necessary it is to recognize and to control variables in order to get reliable results. Page 187 starts the discussion. Apart from such a discussion, it will pay off in later work to keep referring to the idea by reminding the children to look for possible variables and to take them into account in experimental work.

**children
and**



the science of

water

joe elstgeest

Children and Water

Did you ever drop a stick straight down into the water of a canal or a river?
How did it come up again?

Did you ever watch rings going forth from a plunged-in stone, and see them rippling back again?

What happens where outgoing and reflected ripples meet?



Did you ever play with a jet of water?



Did you ever fall into a ditch?

Did you ever stamp hard in a puddle?
(and was your mother nearby?)

Did you ever make mud pies?

Did you ever watch water boiling in a glass vessel?

Did you ever walk in a downpour?

Did you ever race sticks down the gutter?

Have you ever thought about

- how dependent we are on water?
- how much water there is all around us?
- how much water we use daily?

65%



or about how much water you are?

Then you can understand
why this was written.

What do you need?

What can you use?

Firstly you need **water**

Secondly you need **water**

Thirdly you need **water**

And other liquids: spirit, oil, ink.

And things to put into water: salts, soap,
sugar, detergent,
colouring.

And things to put water into: tins,



jars,
tins,
jugs,
droppers,
pails,
basins,
hose,
piping,
spouts,
troughs,

And things like corks,

pins,
needles,
string,
thread,
filter paper,
blotting paper,
squared paper,
news paper,
tissue paper,
(razor blades),
plastic foil,
aluminium foil,
plasticine,
spoons,
trowels,
pieces of wood,
wax paper,
sponges,
mop...
and a floorcloth

Did you know that you can make all kinds of useful equipment out of plastic household "bottles"? Just cut and snip away, and you get tall and flat containers, troughs and spouts, boats and buoys, sprinklers and funnels, strips and snippets, squeezers and squirters, measures and measuring jars and much more, perhaps. Be resourceful!



Infants and younger juniors

They have no use
for "lessons" about
water.

They would
promptly stop
learning.



What they need
is water.

a little supervision and...

materials:

to do:

Funnels,
tubes,
straws,
jars,
jugs,
vessels,
basins,
bottles,
tins with holes.
With one hole.
With no hole.
plastic bottles,
squeeze bottles,
medicine bottles,
plates,
saucers,
spouts.

to pour,
to fill,
to empty,
to sprinkle,
to spatter,
to let run,
to count,
to drop,
to drip,
to carry,
to shake,
to hold,
to keep tight,
to squeeze,
to squirt,
to syphon,
to mess about,
to play,
to try,
to watch.

to suck
up.



can we
really
mess
about?



and soap to
blow bubbles!

Colours
to make
the water
beautiful.

And mud to
make pies.

And many more
things... and odd bits and pieces...

to sink
and
float



to plunge
and
to plop!



to smudge
and to
smear.





Slopping and Mopping!

Oh, but it doesn't have to become a sludgy pigsty!

Of course waterplay is fun, and spatters do splash around, but, really, it is not difficult to let even infants see the difference between a bath and a classroom!



They should
DO.

Can you
fill a bottle
without spilling?



Ten
egg-cups full
of water
fill a plastic
vinegar bottle.



I can empty
a whole
bottle of
water into my
trouser pocket.

Experience



Have
you ever
tried
holding this
and fill it up
with water.

I am sorting
heaps of
floating
and sinking
things.



Miss, when
I stir every-
thing in the
water swirls
around!



I am
always amazed at
how they always
invent a syphon!

and Wonder!

Floating and Sinking

When children work with water and things, one of the first questions usually is:

"What happens if you throw a ... (fill in what you fancy) ... into the water?"

or: What will float?
What will sink?

However, do not leave it at that:



Go beyond the question and WATCH:
HOW does a block of wood float?
or a plank?

Draw it nicely.



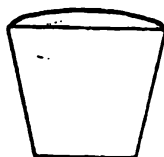
a tin (empty)?
a tin (half full)?
a cork?
a jar?
a piece of styrofoam?
a sponge?
a ping-pong ball?

How much of it is above the surface of
below the water?

Is it lying straight? or tilted? How much?

Where does a cork (or a pin) float:

a) in a full cup?



b) in a half full cup?

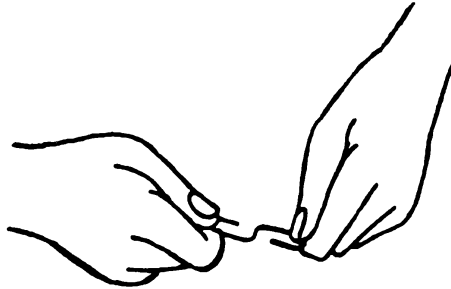


Can you make a pin,
a paperclip,
a needle,
or a razor blade float?



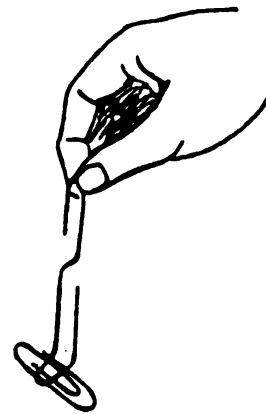
With a simple instrument
and a little patience and
practice, everybody can do it

Open a
paperclip



Use pliers
to make
a little
foot
and

lower
the object
gently
on to
the water



Once you get it afloat,
watch carefully once more:

How it floats.
Where it floats.

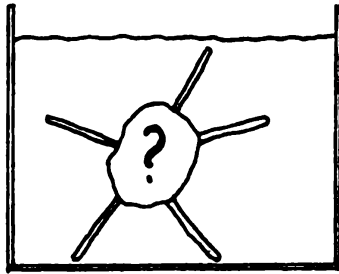


think of
the cups,
full and
half full.



Compare a cork or piece of wood
which floats in water with the
floating paperclip;
look where floating object
and water touch!

Can you make
a sinking object float?



This is a potato with
matchsticks stuck into it...

How many matchsticks
or toothpicks
(and perhaps you can think
of other buoyant things)
are needed to make a
potato float?

And if the
potato is
twice as big?



I have no
matches!



And if I
hollow
my potato
out...?



A ball
of clay
sinks,
but
I make
a little
boat
out
of it!



How can you
make a
stone
float?



A rotten egg
will float!



Whatever children suggest
is worth trying out... although...



How would we
do that with
a stone?

Try
salt
water!



Food-, fruit-, fish- and soup-tins

should never be thrown away, really,
before having been put to good (scientific)
use: - What happens if you place an empty
tin on the water surface?



Then it floats,
of course!

Perhaps...
But how?



- How will it float if it is
high and narrow?



- How will a low and wide tin float?



- Can you make them all float straight up? How?

How much water,
sand;
how many peas,
marbles,
paperclips,
pebbles,
corks,
rubbers.

can you load into
your floating tin
before it (just) sinks?

Is that the same for
every tin?

How come?

With  and  make a hole
two holes
more holes in a tin...
and float it on the water.

Does it still float? For how long?

What happens?

What do you see in the tin?

Measure the time for one hole,
two,
four,
eight holes.

What happens if you put marbles
or pebbles into your tin (with one,
two,
four,
eight holes)?



1) Measure times

2) Tabulate or graph
a number of holes vs. time.
a number of marbles vs. time.

Time for what?



Sardine-tins

bottle tops

shoe-polish tins (+lids)

jam-jar lids

are too good to be
thrown away:

they are first-class
scientific equipment
for a variety of experiments.

They can be used as "cargo boats"

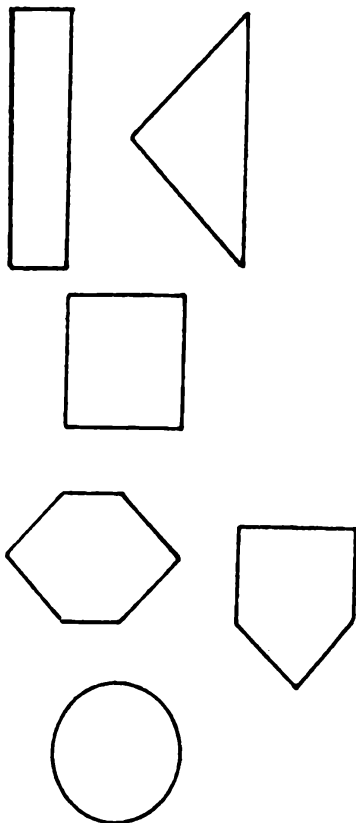


- How many marbles,
pebbles,
sand,
clay,
things

can the boat carry
without toppling,
keeling over,
capsizing,
or sinking?

What else can you load?

How can you load your boat in equilibrium?



It would be nice to make
little wooden "boats",
cut out in different
shapes, but of equal
area.

• Would the shape
of the "boat" make
any difference to
its "loading capacity"?

- Can you pile as many
marbles on a square
as on a triangle? -

• And dry sand?

• And when these
loaded boats move?

• In how many ways
can you make your
boats move without
touching them?

DROPS



How do you make drops?

Or should one ask:
How does a drop
form itself?

What exactly do drops look like?
What is a drop's shape?

Observe very closely:

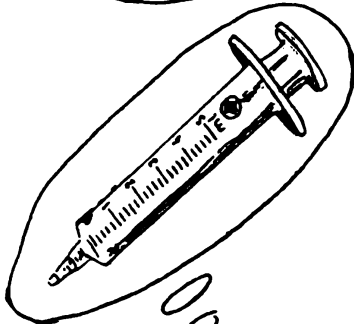
- a hanging drop.
- a falling drop.
- a lying drop.
- a running drop.
- a fallen drop.

If you draw
it with care,
then you know
how well you
observed!

How big is a drop?

Are all drops equal in size?

How do
you
measure
a drop?



Drop
drops
into a
measuring
cup.

How many drops
make 1 or 2 ml?

So, count and divide.



Would
nobody
think of
this?



Once you know how to "measure" drops,
you can compare: which liquid makes
larger or smaller drops: - water?

- milk?

- spirit?

- sea water?

- oil?

- vinegar?

- soapy
water?



I wonder!

Heaping drops

You can heap drops...
but what happens if you do?

Try heaping one drop onto the other:

- using water
spirit
soapy water
oil
milk
sea water
vinegar

on to plastic
glass
wood
your arm
metal
foil (aluminium)
rubber
paper
waxed paper
makintosh cloth



Have you ever
tried dropping
drops on dry
sand?

Drops soak into
blotting paper and
make rings

- newsprint or
coffee-filter
can be used,
too.

Would this be a
reliable way to
measure drops?
And to compare
their size?



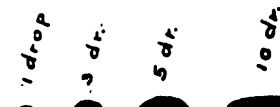
Look,
Compare,
and draw accurately
what you get:

a) Water _____ ?

on plastic ?

b) soapy water _____ ?

on glass ?

c)  _____
Water on waxed paper.

d)  _____
different liquids on
waxed paper: 1: Water;
2: spirit; 3: soapsud; 4: oil.

e) idem.. _____ ?

on aluminium foil.

f) whatever it is... _____ ?
on whatever it is... ?

What is the
difference
between drop
and drip?



How full is full?

Collect some small ves
like bottlecaps:



screw-tops:



small cups;

lids of jars...etc.

Then try and see how many
of water,
of soapy water,
of spirit,
of vinegar,
of oil you can add to a j
before it overflows.

How high can you "heap"
the liquid above the rim?

You can make use of

- eye-droppers,
- injection syringes.

They are good
for measuring,
I told you!



- or, if you are clever enough,
ordinary drinking straws

Which drop makes the bucket
overflow?

The last
one,
I guess.



What happens if...

you "heap" ordinary water above
the rim, but not quite as high
as you dare, and then add a
tiny drop of ... soapy water ?

or any other liquid.

Racing Drops

Let drops drip and run...

- along little slopes of different angles,
- and made of (sheets of) different materials, such as plastic, wood, formica, glass, slate, metal,

and watch well !



Observe: how the drops run.

- Do they run straight?
- Do they run fast?
- What does their speed depend on?



And if you change the angle of the slopes?

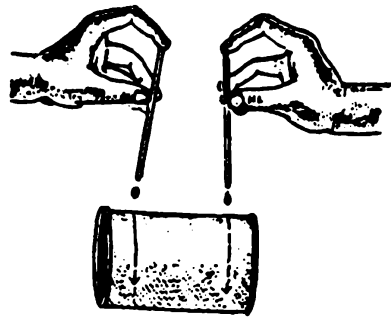
Or if you use different liquids? Oil? Spirit?



And now for the races!

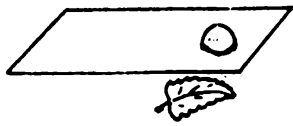
Take sizeable tins, pots, buckets, bottles, or vats and let drops race each other down the curved sides.

Which drop of which liquid becomes champion?



- Can you find a way to make a drop win?
- Could you use straight-sided vessels?
- Could you use sloping sheets?
- How could you make drops run straight?
- Have you tried drops of ink?

What more can you do with drops?



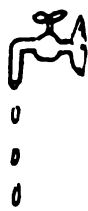
You can make a pretty good hand lens:

Place a nice, clear drop on a piece of transparent plastic, (overhead projector sheet)

Try it out as a lens:

- At what distance above the object should you hold it to get it into sharp focus?
- How much (or little) can you see of your object through the water lens?
- Can you make your drop-lens any bigger? better? rounder? clearer?
- Would another liquid (e.g. oil) make a better lens?

Whatever you find: a water drop lens comes in handy when you have no hand lens on you.



A dripping tap is a clock.

How can you adjust such a clock?

= How can you measure time ...
... with a dripping tap?

Out of tins you can make water clocks:



A tin with a hole?

But... wouldn't you get a stream of water?

And if you cover the hole with filter paper?



You could let the water syphon through a cotton thread over the rim into a measuring jar (home-made?)



How do you wind these clocks?

How do you keep them running?

Spatters

are splashed drops.

Use coloured water



Beetroot juice is cheap.
Inks and dyes are dear.
Watercolours are expensive.
Foodcolouring "clean", but
rather forbidding.

What happens with drops which are
dropped from a height of 10 cm,

25 cm,

50 cm,

100 cm,

150 cm,

200 cm,

onto paper?

wax-paper?

glass?

plastic?

stone?

linoleum?

Goodness me!
Shouldn't
you rather
go outside?
The mess!



or... into a pan of water?

or dry sand?

Coloured spatters you can save.

They "write" their own records...

... but you should write the "what happens if..." question
next to them, otherwise you save answers
without questions

You can also measure them
and make a graph



Look at the
question above
and the spatter
below!



Measure
what, sir?
Graph
what, sir?

If it rains,

you get
many
drops
for nothing!



Use them!

- Watch how the rain falls:
 - straight down?
 - slanting?
 - how obliquely?
 - what would make the rain slant?
- What happens to raindrops when they drop down?
 - Look low, just above the ground, where they hit the earth
 - and where they hit the surface of a puddle
 - What, precisely, can you see happening where a drop hits the water in a puddle? (or a pan?)



Could you describe "a puddle in the rain"?
or paint it?
or draw it?
or sing it, if you wish!

- What colour has the water in a puddle?
 - can you copy that colour?
- Go and stand somewhere else:
 - what colour has the puddle now?
 - can you copy this colour, too?
 - Look around and see if you can find something else of the same colour.

Try it



What is hard
when it rains hard?

If it keeps raining...

- What does the rain, or the rainwater, do to the ground?
- Look on the path,
- on a bare patch,
- in the sandpit,
- under the tree,
- in the grass.

Where does the rainwater leave the clearest tracks?

Did you look where the ground slopes?

What would cats and dogs do to the ground?



Could you make a mini-river system yourself on a sloping sandy patch of ground? Even on a dry day?

- Where does all the rainwater go?
- How do you know?
- Can you think of some way to "follow" the water?

Are all raindrops equal in size?

Stick a piece of paper outside; hold it flat into the rain... for just one second...

- What can this bespattered paper tell you? ...about equal or unequal sizes?
- How many drops did you catch?
- Could this small experiment tell you something about (what is) "gentle" rain or "hard" rain?
- Measure the biggest spatter, the smallest, the one which occurs most.

What exactly happened to the raindrops hitting the paper?

Does this also happen when they hit glass? plastic? stone? dry sand? a mackinEosh? a handkerchief? bare skin? kinky hair?

The Mathematics of a Shower of rain.



"This is heavy rain!"

How do you measure rain?



With a rain gauge, of course!

How "of course" is the rain gauge?

What do you want to measure?

- The size of the drops?
- The amount of drops?
- The quantity of water that has fallen?
- The amount of rainfall at a given time and place?



What can you measure

- With a rain gauge?
- With a good, straight-sided, tin?
- With your "spatter-paper"?

What means: "3 mm rainfall?"

The rest you have to calculate or to estimate.

Now calculate:

a) The area of the school's playground.

An estimate is like a measured guess



b) If the rain gauge measured 2 mm of rainfall, how many litres of water fell on the playground?

And if the whole shower fell on an area of 1.5 square Kilometres, and measured 2 mm, how heavy was that shower?

If n drops drop on your paper (A4) in one second, how many drops, then, drop on your playground from a shower lasting 10 minutes?

Water and Dye

Water is a fluid...
...but how does it
flow?



Movements and currents
in the water are usually invisible...
until you drop a crystal of dye,
or a drop of colouring (or ink)
into the water



What does happen if
you drop a drop of
dye or ink in a glass,
or a basin, of water?

TRY and WATCH

By this simple technique
-or trick- you can draw quite
a few secrets from the water:

- How does water move?
- How does water mix with another liquid?
- How do currents run, or flow?
- How does the water at the top of the kettle heat up?
- How long does water which has been stirred turn round and round?
- or how long does water "remember" in which direction it was stirred?
- How does a crystal dissolve in water?
- How does a dissolved - or a dissolving - substance (solute) spread through water?
through moving water?
through still water?
through cold water?
hot water?
heating water?

Water
and dye
help you
solve these
problems.

Water running upward ?



That is impossible!

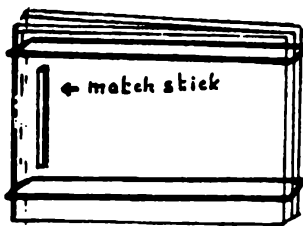
Oh no!

Oh yes, it can!

honest!
I swear!



Take two small glass plates,
and, at one end, you stick
a match stick between them.



Next, tie them together with
rubberbands

Now touch, with the underside
of this contraption, the surface
of the water in a basin...

What happens to the water
between the glass plates?

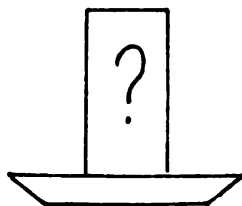
Draw it. Describe it.



Well, what
did I tell
you?



So what?



What happens if
you stand a brick
in a plate, pan or
pot of water?

- or a rock?
- or a broomstick?
- or a piece of chalk?

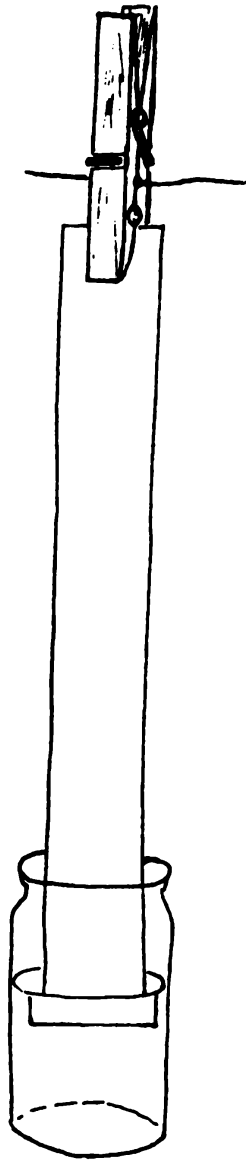
Let water climb

up a strip of paper

and you will find
many problems
to be solved by
as many experiments:

In what paper does the water
climb highest?

- In blotting paper?
- In newspaper?
- In copybook paper?
- In kitchen paper?
- In wrapping paper?
- In wall paper?
- In toilet paper?
- In filterpaper?
- In doesn't-matter-what-paper?



If you hang
these strips
in a row, you
automatically
get a graph.



And how does
water climb

- high or low -
in strips of

- cotton cloth?
- wool?
- nylon?
- plastic?
- felt?
- canvas?
- muslin?
- linen?



And in strips
of trouser leg?
of shirtsleeve?
of coat tail?
of an old sock?



I try it in

- coloured water
- sugar water
- salt water
- oil
- spirit
- lemonade
- milk

... if I am
allowed to...

Variables



A Variable
is a quality
that may
or may not
differ.

If you want to make valid comparisons, and so assure yourself of dependable solutions to your problems, you should compare only one possibly different quality at the same time.

Example 1: to solve the problem:
"Which liquid rises highest?"

you may use:

different liquids,

but: the same paper
of the same width,

dipped to the same depth in the liquids.



and put
them in
the same
place!

Example 2: to solve "How does the width of the strip affect the rise of the water?"

you must use the same kind of paper
and the same liquid, and dip
the strip to the same depth in it.

Only the width of each strip may differ.

This is called
"Controlling the
Variables" in an
experiment.



I control
a whole bunch
of variables
every day!

Keep this in mind, and you can solve many problems.

Like: How fast does a liquid rise in

(How far) - different papers ?
- different textiles ?
- different bricks ?

And: How fast do different liquids
rise in --- papers ?
textiles ?
bricks ?

How would you control variables here?

And there are plenty other problems:

Listen!



How come
the liquid
stops after
a while?
Does it
dry up?



Would it get -
higher up
if we wrap
thin plastic
foil around
our strips?

You can
hang
your strip
inside a
bottle and
cork it!



I can let
water
creep over
the side
of a jar
through a
thread of
cotton.



I am going
to make a
strip of
filter paper,
and let the
water move
around a blot
of ink

How does
water move
up a round
piece of
paper?

Or through -
a star-shape,
or a zig-zag?



I put
three
colours
in my
paper-
strip

I make a
paper with
a hole in
it! No,
three holes,
no, four!



How "strong" is water?

- You can "heap" waterdrops.
- It carries paperclips, needles, razorblades.
- Water "pulls" itself up.

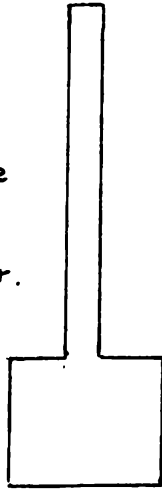
Is water "strong"?

How "sticky",
clinging,
or tenacious is it?



And have you
ever tried to
separate two
wet plates of
glass?

Cut
this
shape
out
of
paper.



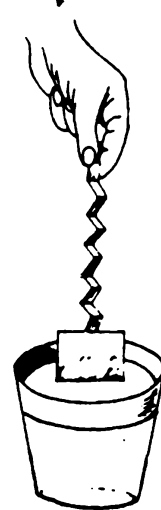
and
fold
the
tail
zig-
zag:



and you get
a water surface
tension meter.

It also "measures"
possible surface
tension of other
liquids: at least
you can compare.

Just touch the surface,
and gently pull upward:
how far does the zig-zag-
spring extend?



Can you think of a more reliable instrument?



I would try
a light
spring balance

Wouldn't
it be
better
to use
something flat with it?



Yes, because
there is more
surface for
the water
to hold on to!

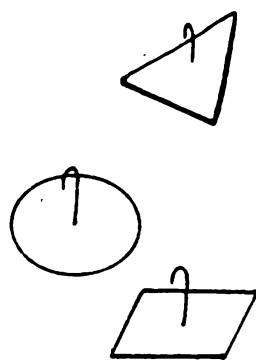
How about adding
washers to a
floating razor-
blade?



Or...
shall we use
a proper balance?



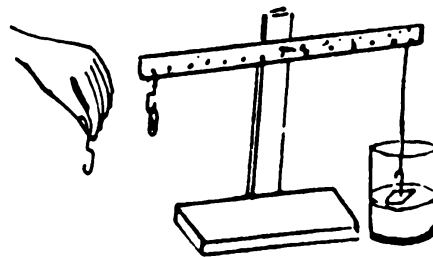
The surface tension balance



Cut regular shapes out of strong paper or card — which you can make waterproof by dipping it in hot candle wax — or out of plastic or metal sheeting.

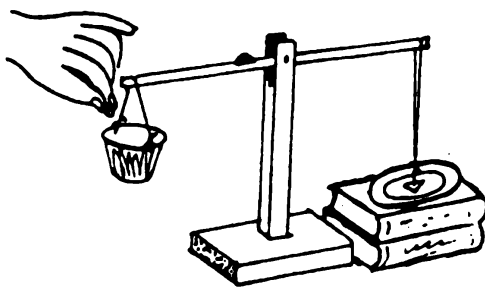
Fix a pin through each figure's centre point, and bend it to make the shape suspendable, and keep it in balance.

Suspend one figure, on a thread, from the balance, and bring the balance to equilibrium first. Then let the shape just touch the surface of the water.



Now add units of weight (e.g. paperclips) to the other balance-arm, and count how many are needed to pull the shape free from the water (i.e. hold).

Now you can compare and find out to what extent shape, size (area), or even kind of liquid, affect the liquid's (the water's) "holding power".



Try and make different shapes with the same area, and different areas of the same shape.

Mind the Variables!

When you consider solving problems like:

- Is soapy water stronger, or..?
- Is one shape held more "tightly" than another?
- How can you compare the water's pull on different areas?

Which variables should be kept constant, and which one may vary?

ICE. WATER. STEAM

Where
does boiling water
go? Can you retrieve it?

There is a classic experiment
whereby a cold plate is held
in the jet of steam coming
from a whistling kettle...

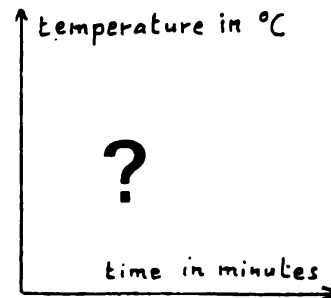
I find this rather dangerous
for children! Even teachers
burn their fingers!



A surprising investigation is:

What happens to the water's temperature
between ice and steam?

- Start with a pan of iceblocks (+ water).
- Hold a thermometer in it and from now on take a reading every minute.
- Keep a careful record of the temperatures.
- Heat the pan on a steady flame, or on a hotplate, and let the water boil for at least five minutes.
- Make a graph.
- What does this graph tell you?



My children love
making ice cubes
in the freezing
compartment of
a refrigerator.

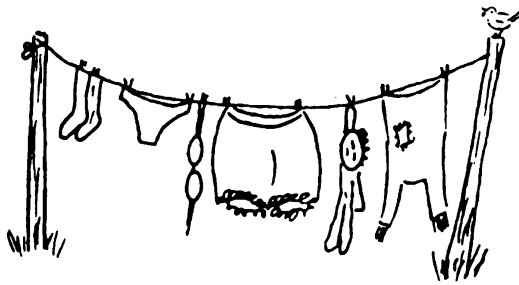
I have sent them
off with the problem
of making ice balls,
or ice eggs,
or ice rings,
or, indeed, any shape.

Miss, how
can you
keep the
air bubbles
out of the
ice blocks?



Evaporation and drying up.

Drying the laundry seems so common, but what exactly happens when the wet clothes dry?



What is 'drying up'?

How wet is wet?

How dry is dry?

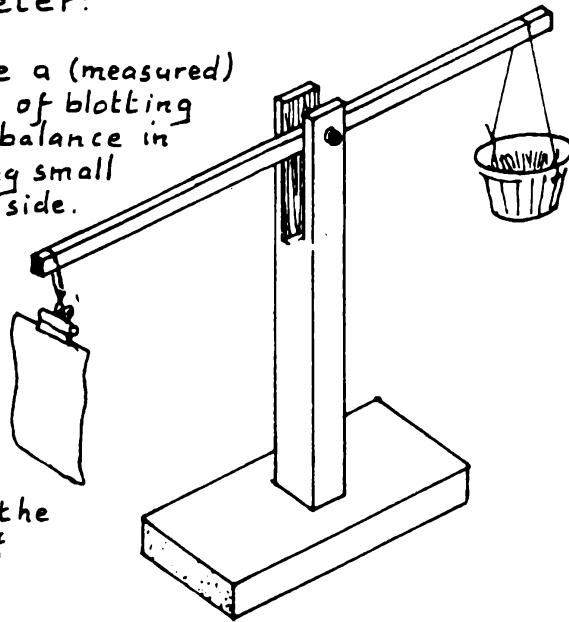
Can you measure wetness?

Out of a simple balance you can make a good wet-and-dry meter:

Suspend on one side a (measured) wet cloth or piece of blotting paper. Bring the balance in equilibrium by adding small weights to the other side.

When drying, the object loses balance, and the balance loses equilibrium.

This enables you to measure the time it takes, as well as the quantity and the speed (or rate) of evaporation.



(P.S. Weigh the dry object first: then you know how much water it still retains: 1cm^3 water is 1 gram)

Now, thinking of variables (which ones?) you can solve: 1. Does the place (position) make any difference?

In the sun? the shade? the draught?

On the cupboard? In the corner? Under the table?

2. Does the shape make any difference?

Circular? Square? Triangular? Ribbon-like?

3. Does the area affect the rate of drying up?

N.B.: Cut same shapes, different areas;
same areas, different shapes.

Is this the end?



There is no end, of course,
because many questions and
problems remain.

There is much more to be done
with, and much more to be
learned from, water.

Think of: - Waterpower

- making turbines;
- study erosion;
- work on pressure;
hydraulics.

- Water cycle

- Water preservation

- Water works

- make a water -
distribution map;
- dismantle and
assemble a tap.

- Water pollution
& purification

· Filtering

- Solutions and
Solvent (s)

- How many sugar
lumps dissolve
in hot water?

- cold
- What do you get
if you evaporate
sea water?

And whatever lives,
lives not,
lives no more
in the world's waters.

Everything is important,
is interesting,
is instructive,
is relevant.

Fit in any topic which
catches your children's
attention, or yours.

Just get started,
and see where it ends.



Children and their environment

Introduction

The environment of every school is full of interesting features, full of information and full of illustrations. It is also rich in materials to work with, almost all for free. As a rule, the school environment is very close (and appropriate) to the daily experiences of the children in their own familiar world. The familiarity of the environment might be a drawback in so far as it can lead to taking things for granted. Some effort is therefore required to delve into the unknown parts of this well-known place.

This effort is required from the pupils in the first instance, for they must learn to ask questions which are not always obvious in an everyday environment. They must also learn to look for and find satisfactory answers to their questions. Fortunately, answers to appropriate questions are hidden within this environment and can be uncovered with the right kind of scientific exploration and endeavour. Whatever the children uncover, they also discover, and they delight in discovery. This kind of discovery through scientific endeavour and discipline takes away the odium of randomness, often mistakenly associated with the idea of 'discovery learning'. Endeavour can be planned.

This means that the teacher, too, must make an effort. Not only does the teacher have to make a biological or ecological survey of the school's immediate surroundings, he or she also has to recognize and measure its potential for children's activities in their learning of science. It is the teacher's task to stimulate, and often to formulate, the questions or problems with which a living environment confronts children.

This chapter presents a number of suggestions and ideas about doing science in the neighbourhood, in the surroundings and in the environment. It attempts to give an answer to the question: 'How can we help the children to use their own environment as a source of learning?'

It does not provide 'ready-made lessons' simply because it would be impossible for an outsider to make these up. Every school's environment is different from all others and therefore unique. Having explored the school environment, teachers must make their own activity plans according to the possibilities and opportunities offered by this environment.

The aim should be to help the children to approach their environment, or aspects of it, with a new scientific look, so they learn to view it as a whole, in all its complexity. Some activities suggested in this guide do just that: working on a minifield, or a transect, means observing it as a community in which we try to unravel relationships and interdependence, and other influences. We start, however, direct from the touchable, observable and very concrete materials and situations of our children's real environment.

On pages 201 to 203 are ideas, often in the form of questions, about how to study a minifield (a small patch of ground, clearly demarcated in some way) and how to relate observations to each other to find relationships. Questions are suggested which can be answered by looking carefully and which will, of course, lead to other questions. Variations in the study of minifields (page 204) are proposed as starters; teachers and children will think of many more.

What is suggested for working with minifields is of equal relevance to the other activities and exercises described in the chapter, since they are basically similar in approach and technique to the study of minifields. They lead, however, to more comprehensive results and, hopefully, to pleasant and motivating surprises. Some such surprises were expressed by a group of teachers who, during a workshop at their school, attempted the exercise named 'A Biofield in Layers' (page 205). An interesting area was chosen at the edge of a stretch of woodland where the undergrowth began to give way to open grassland. The teachers were told to study the area in detail, to sample samples where desired and to prepare an accurate map, illustrated with sketches, drawings or real samples.

The first group was assigned to the area 'underfoot'. This meant that they studied no more than the soil and what was immediately on it or in it. Their attention was drawn to the thicker layer of humus in the wooded part, of which they took a sample for display together with their presentation afterwards. They also dug up a number of roots and root systems, rhizomes and creepers, which on closer scrutiny revealed not only a surprising variety, but which also clearly indicated a visible relationship between form and function. What they had formerly dug up from schoolbooks they had now dug up for real, and their comments expressed satisfaction: 'I am going to do this with my children.'

Members of the second group, restricted to the lower five centimetres just above the ground, were surprised at finding species of plants which grew no taller than a few centimetres, yet were complete: flowering and seeding. The elbowing action of leaf rosettes came to their attention and the question

'Where does the stem of a plant begin?' led to a fascinating investigation and discussion. The group studying the layer between knee- and shoulder-height became interested in the aerodynamics of a swarm of midges dancing above the grass, something they would normally have passed by without noticing. The group mapping what was found above eye-level expressed surprise at the great variety in size, colour and even shape in the leaves growing at the ends of branches of shrubs of the same species.

These teachers, like most others, were not field biologists, but they were motivated by the unfamiliar approach to something they had walked by for ages without taking much notice. The most pleasant surprise, however, came when they presented and displayed the records of their findings: five annotated maps, filled with sketches and fresh samples, which contained so much more information than they had expected and revealed such a high degree of creativity that they made two comments: 'Can so much information be found within so small an area?' and, looking at the five very different representations of this same area: 'Have we done all this?'

Working on a transect (pages 206 to 209) leads a step beyond the closer community of living things in a minifield. A transect is more suited to the study of the vegetation across a larger area; it gives an overall view rather than great detail. A sequence of changes in vegetation across a piece of land can often be related to visible conditions like the composition of soil, exposure to wind or sunshine, tilt of the land, or disturbance by passers-by or cultivating machinery.

When studying 'vegetation', one considers the collective plant cover rather than individual plants. Vegetation is more than just the plant cover of an area. It gives the landscape (or landscape elements like an embankment, the verge along a country lane, or the swampy edge of a pool) its own colour and character, along with prevailing physical and climatic conditions as well as the influence of its inhabitant fauna. The lonely ant who happens to pass by is of little importance, but the wriggle of eating caterpillars certainly is to be taken account of.

From page 210 onward attention turns from the field to plants as individuals. Considerable emphasis is placed on using the actual plant as a first source of information about itself. What does the plant *tell* about itself? To answer this question, which keeps returning in different guises, the student (child as well as teacher or trainee) is required to observe the plant and its features accurately and in great detail. However, observation is only a first step, for the student must now attempt to look through what has been observed in order to gain insight into such relationships as exist between form and function of various plant structures, or between the plant and outside (situational) influences. This requires thinking and reasoning, putting acquired concepts in order so that an intelligent hypothesis can be formed and formulated. It calls

for comparing and finding similar structures related to similar functions. Further work may lead to simple experimentation.

The role of language (plant words) is placed in its proper position: as a vehicle of thought and a means of communicating findings. Classification of plants is presented not as a matter of fact and a completed system, but as an activity to be done, requiring skills of observation and ordering. When classifying plants, students observe similarities and differences, and by discussion they establish criteria for grouping their plants on the basis of observable characteristics. This means that they must make decisions on which features are relevant to establish 'likeness' or 'difference' in relation to inclusion in, or exclusion from, a certain group or 'class' of plants. Linnaeus might smile at the result of such activity done by a group of children, but he would be delighted by the method.

Finally, some activities on animal life are suggested with great emphasis, once more, on observation and finding relationships, particularly with the environment.

Children

do Science



in their ENVIRONMENT

Jos Elstgeest

Children orient themselves in this world. Continuously they try to accommodate themselves among the many living and non-living things, forces and powers, mishaps and successes, natural phenomena and unexpected events, illness and bad weather, joy and grief. They are surrounded by multitudes, and they want to make sense of it all by figuring out relationships, connections and explanations. They adjust themselves and their behaviour accordingly. They try to conquer their world by attempting to understand it in all its multiplicity and complexity.

The environment is the children's own: they live in it, they play in it, they belong to it, they are familiar with it, and they learn in it. This familiarity may give the false impression that they know all about it. They do not, of course, and they have to be prodded to learn more from it, and so about it.

In these worksheets you will find a number of suggestions and ideas about doing science in the neighbourhood, in the immediate surroundings, in the environment. They attempt to give an answer to the question: 'How can we help children to use their own environment as a source of learning?'

You will not find 'ready lessons', simply because it would be impossible for an outsider to make these up. Every school's environment is different from all others and therefore unique. Explore your school environment, which you share with your children, and make your own activity plans according to the possibilities and opportunities offered by this environment.

Help the children to approach their environment, or aspects of it, with a new, scientific, look, so they learn to view it as a whole, in all its complexity. Some activities suggested here do just that: working on a minifield, or a transect, means observing it as a community in which we try to unravel relationships and interdependence and other influences.

We start, however, directly with the touchable, observable and very concrete materials and situations of our children's real environment.

Working on a minifield

- Choose a piece of ground which, for some reason or another, looks interesting.
- it need not be of uniform appearance.

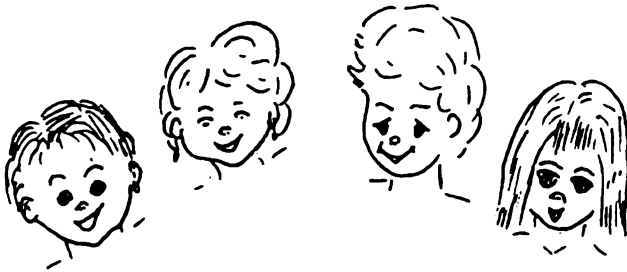
Use sticks, slats or string to mark or peg out a square of, say, 1 x 1 metre.



I use a hoop, that gives me a round square metre.

Now study this minifield carefully and map it:

- What lies there?
- What sits there?
- What moves there?
- What crawls there?
- What creeps there?
- What grows there?
- What digs or dug there?
- What lives there?
- What made a home there?



This is nice group work!
Let's work together on it.

If you take a convenient shape and measurement, then it is very easy to map things accurately: various kinds of plants, objects, stones, holes, seeds, fruits, seedlings, animals, droppings, peels, throw-aways, and other bits and pieces.



I lost my red pencil recently...

Try and see

if you can find relationships
between any of those things you find in
your minifield:

Relationships...

... between individuals of
one kind,



Miss, what
is a
relationship?

... between different kinds.

... between plants and animals,

... between plants and people,

... between plants and things,

... between animals and people,

... between animals and things,

... between things and people

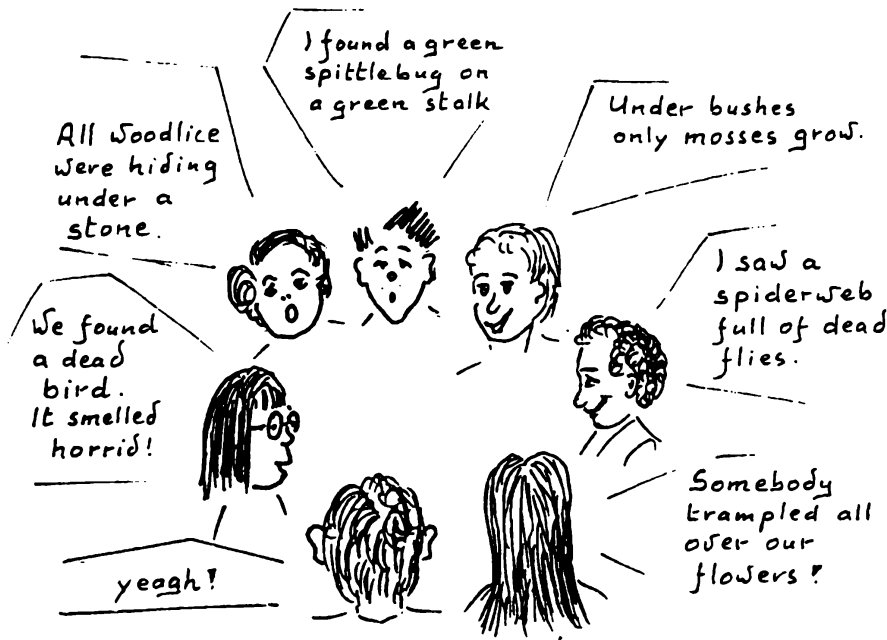
Look
for
a
"because"



Could you write down what you find or think?

You may draw, or sketch, or paint to make it clear.

Better: talk about it first:



Look also for relationships
between (things within) the
minifield and (those in)
the larger world without.

Perhaps
somebody
passes through
your minifield..

- Where from?
- Where to?

Seedlings come from seeds ...
From where come the seeds?
Can you find parent plants around?
Where? Many? Far away?

Leaves lying about ... Were blown from where?
Can you find trees somewhere near?
Do they have similar leaves?

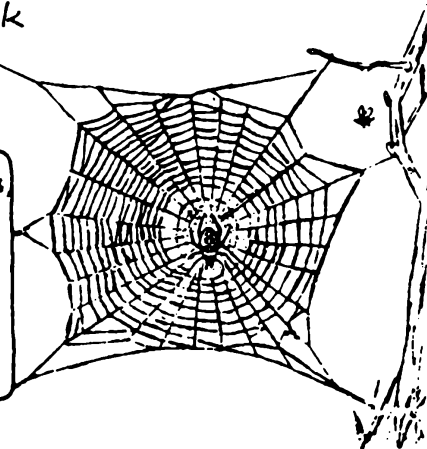


Look carefully, too, at what sits and lives
underneath, and at the bottom of
your minifield ---

And do not forget to look
at what hangs above it.



In other words,
study your
minifield
with great
care, but
not in
isolation!



If the children compare their findings
recorded on their minifield maps,
it would add meaning to their conception
of the character of a larger area.

Minifield and Maxi-use.

My little ones
love choosing
pretty, flowery
minifields...
and then picking
them bare!



Mine
just make
their own
minifields:
if they find
there is no flower,
they go and pinch
them from elsewhere!



My children
studied mini-
fields at the
edge of a
wheat field.
Surprise?
Try it, too!



My nine-year-
olds just love
separating and
sorting "sorts".



We made a
vegetation study
of 3 larger areas:
a wood, a hillside-
wasteland, and
an embankment,
by sampling and
comparing minifields.
Then we spread out all
maps in the assembly-
hall.



My class
"adopted"
minifields
for a year.
Each child
returned to
his or her "own"
minifield every
season and kept
good records of
what was changed
and what was perma-
nent.



A long string
of minifields
works like
a transect
and it does
not have to
be a straight
line.



Our teacher gave
each of us a
minifield to seed
in his garden!
We could keep
the weeds, he
said.



A Biofield in Layers.

Look for an interesting spot somewhere nearby where there is plenty of growth.

Peg out a small area of some 2 x 2 metres.

Ten to fifteen children (students) can work on this.



Form small groups and divide the work: to map this area in 5 layers.

Group I maps the area underfoot.

Group II maps the area as far as the ankles reach.

Group III maps the area up to kneelevel.

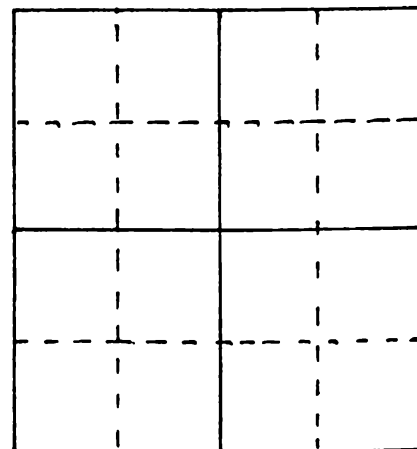
Group IV maps the area at shoulder level.

Group V maps the area above eyelevel.

- Collect your information with care: whatever you find noteworthy.
- Make notes and fill in a rough sketchmap.
- You may (where this makes sense and is not sinful) collect samples.
- Take everything back to the working table (classroom) and complete the map of the assigned "layer" and embellish it with relevant samples.



It helps to subdivide the map of the area.



Working on a Transect



A transect "cuts across",
makes a transverse section of,
a piece of land: a landscape.
It is a means of making a more
global study of a larger area:
more detailed than an overview;
less detailed than a minifield.

Choose an interesting stretch of land
in an area which shows some transition:

- e.g.:
- changing vegetation
 - the edge of a cultivated field.
 - across a ditch, a dune, a dike,
a dam, a wall, an embankment:
(usually to compare influences such
as exposure to sunshine or shade,
or steepness or swampiness or...)
 - the edge of a wood



span a string across the area or
feature you wish to investigate.



Limit your observations to a maximum
of 20 centimetres, or less, on both sides of
the string.



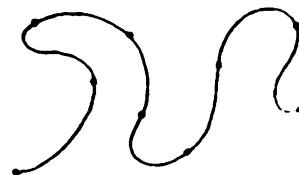
For beginning
children it is
good to use
colourful ribbon.
I often stretch
two ribbons or
strings, about
30 to 40 centi-
metres apart,
running paral-
lel.

I tie knots
in the string
at one-metre
intervals.



This makes
it much easier to
locate features
accurately and to
map them
correctly
afterwards.

Oh, they find it too
difficult to leave out
something interesting
which is "out of bounds"



Now for the difficult part.

A transect is meant to bring the investigating child nearer to understanding the web of inter-relationships between living and non-living things and all sorts of other influencing factors. This might begin to reveal something of the nature of transition and change.



Right, but first things first:
Children must first learn to register carefully and properly those findings which matter, which are relevant.
They must be helped to find what is relevant.
Questions and suggestions like those that follow will help.

There is one general question, to which all questions of detail are related, and that should be kept in mind throughout:

"What do the things, the changes, the differences, the occurrences along this line 'tell' me about this stretch of land and what lives on it?"



Shall we take plastic bags with us?



What for?



Well, to pick up rabbit-droppings!

Questions to keep looking...

- What grows/lives here?
- How does it grow? in clumps? in bundles?
climbing? twining?
creeping? spreading?
... or firmly on its own?
solitary?
or many together?
- How many plants of the same kind?
- How many of a different kind?

N.B. a kind is
often called
a species.

If you cannot
count them,
don't worry:
just describe
that in terms
of "many",
"more" or "most"



- Are all plants of
the same species
of the same height? or the same colour?
- In what does it all grow?
- Where you see a change, e.g. of vegetation,
does the soil show a difference, too?
In colour? in composition? in texture?
- Which other things obstruct or influence
growth of vegetation?
 - rubbish?
 - rocks?
 - passing people?
 - water?
 - burning?
 - cutting? or mowing?
- Is the land facing
 - North?
 - South?
 - East?
 - West?
 - the sea?
 - a mountain?



How warm (cold) is it here?

How wet,
How moist,
How humid
is it here?

at grassroot's
level?



How open?
How overgrown?

How sunny?
How shady?

How windy?

How far was this
area left undisturbed?
Or trodden? Or flattened?
Or mown, picked, eaten?



Where
is "here"?

How do the plants "move"?
Upward? Sideways? Spiralwise?
Do they root at every node?

Do not forget: trees are
plants, too, and so are the
algae growing on them;
so are the mosses, liverworts,
toadstools, moulds, lichen...

Do you find bulbs, tubers,
rhizomes in the ground?
Are any fruits or seeds
attached to the plants?

Do other creatures
(or things) lie about,
move about, creep,
dig, bore, cling, stick
or hang about?

What did walk,
sit, gnaw, eat,
spit, defecate,
moult, shed hair,
or leave other
things or
tracks?



Remember:

These are
guiding and
"helping-to-look-"
questions.
You cannot measure
everything everywhere.

Sample data where
you find them relevant,
e.g. to compare one
end of the transect
with the other, or
a lower part with a
higher.

Measure temperatures:
underground (to 5 cm)
and on the ground.



Measure relative humidity
off the ground and among
the vegetation.

Soil can be smeared
on paper (the map!) to
show its colour.

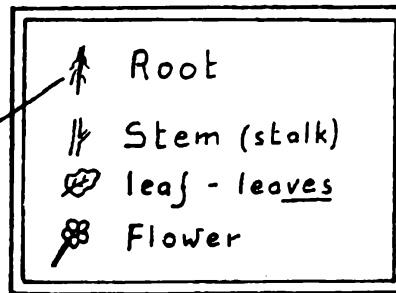
To preserve substance and
texture, "trap" a little soil
under scotch tape or a tiny
plastic bag stuck to the map
at the right place.

To map a transect use a long
strip of paper. Indicate the metres
(knots!) on a convenient scale, so you
can keep relations of space and
size with accuracy.

Map your findings (sketches, samples,
notes, smears) carefully, either on a
proper map (bird's-eye view) or a longi-
tudinal section (side view).



What are
little plants
made of?



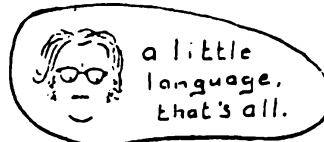
But...

... is it really that simple?

Would it be a matter
of words only?

What exactly do you know when you can
recite this short list?

And the plants
themselves...



What can they tell us?

Does not every plant tell us its own story?



But you cannot
study each and
every plant!

Of course you can
not, but you
can learn to
"listen" and
be observant
to what the
plants have
to "say".



Start by paying attention
to the structure of the
plants you meet:

How do form and function relate?

Form and Function

What does (the) form reveal
about (the) function?

When investigating plants and their parts,
keep questions like the following in mind:



- What does it look like?
 - What does it resemble (if anything)?
- How is it "put together"?
- How do its parts fit together?
 - How are they joined?
 - Space, distance, angle?
- What does the plant consist of?
 - Wood? Fibre? Edible green? Coloured parts?

Especially when considering parts of a plant:

Thinking,
Hypothesis,
Experiment.
That is good
Science.



- What could be its function?
 - What purpose does it serve?
- Is this its function?
- ...What makes you think it is?
- Could you verify this? How?
- Could it be different?
 - Are there different forms having the same function?
 - Are there similar forms having different functions?



What do we
do with such
abstract ques-
tions?



Well, find a
plant and
make them
concrete.



There are various ways of doing this.
Two examples of possible activities follow.

I: Ask and Compare

Go outside and collect some (3 to 5) common plants. Dig them out carefully, wash and rinse them and put them down one next to the other...



We should keep our roots on, shouldn't we?

Look for what is the Same,

(and different) in form
in structure
in attachment
in coherence
in colour
in length
in thickness
in cross-section
in circumference
in strength
in turgidity
in composition
in arrangement

Keep asking the form-and-function questions.

Use a hand lens and note all details:

Do you notice prickles ?

Where
can you find
them?

hairs ?
stings ?
thorns ?
fibres ?
fluff ?
vines ?

How
are they
attached?

scabs ?
bumps ?
ridges ?
grooves ?
stripes ?
holes ?
pits ?

What
function
could they
have?

rings ?
knots ?

How many
can you find?

wax ?
fatty stuff ?

Can you count
them?

stickiness ?
scars ?

And what
else do
you find?

hooks ?
patterns ?
spots ?

- Where do the roots go over to become stem?
- How is the leaf attached to its stalk (petiole) and the stalk to the stem?
- How does the stem branch, or grow branches?
- Where and how are the flowers attached?
- What shape do the cross-sections of stalks
roots
stems
leaves have?
- How many colours do you find in a plant?

II: Every Plant wants to become Something.

Every plant is equipped to germinate,
to grow,
to bloom,
and to reproduce.

But... no plant lives alone
Everywhere there is a struggle for life ---

What does the plant itself tell about
its determination to live, to survive
and to reproduce?

Structure and form of the whole plant,
as well as of any of its parts, reveal
something of these functions of survival.



What can you understand of this tale?
--- or make comprehensible?

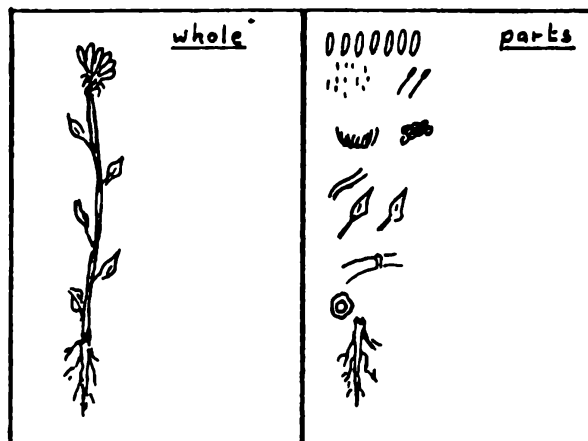
Go and collect each two entire plants
of the same species.

Then make a double
piece of work :

On the left:
What does the
plant as a whole
tell about itself?

On the right:
What does each
part contribute
to this story?
(=natural history)
or: What does each
part tell about
itself and the
whole plant?

Repeat this
with another
species of plant.



If children use
different species
of plants, they
can arrange
their work so
that many plants
tell their story:
let them compare.



Plant words

It is good for children to collect certain words, names and terms, and become familiar with their meaning and their use, so they can



Terminologia
botanica

a) better understand the biology of plants,

There are:

b) better remember important details,

Do-words:

- Mow, grow, sow.
- Bloom
- Bud - - -

c) better distinguish between species, or kinds, when appropriate,

d) better communicate.

Thing words:

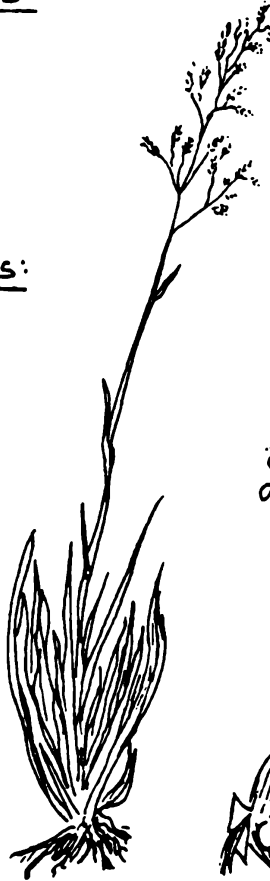
- Berry
- Bud
- Blossom
- Axil
- Vine
- Petiole

Name words:

- Moss
- Fern
- Grass
- Pod
- Petal
- Heather

Names

- Teasel
- Tulip
- Parsnip
- ...or even
- *Capsella bursa pastoris*



Children like making their own "plant book" in which, besides gathering all information they want, they can also collect their plant words alongside pictured or preserved plants. Allow them patiently time in plenty to "complete" it to their own satisfaction.

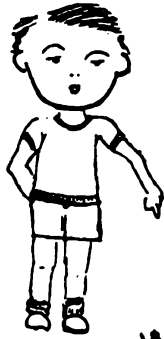
Oh, I never finish!
I keep adding fresh pages because I keep finding new words and new plants!



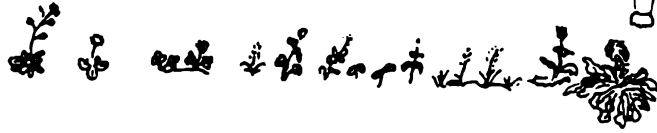
TAKE CARE!



The plants are and remain important. Words only serve.



WHERE do all those little plants come from?



Any bare patch of ground..
Any dug-up flowerbed...
Any freshly weeded front garden...
fills up with little plants in
what seems to be no time... Weeds all over!



Plants
you plant.
Weeds
you weed.

It certainly is a fascinating problem

- Do go and search around your neighbourhood:
where do you find many plants of one kind
together?
- Can you find "parent plants" and "offspring"
growing side by side?
Do not only look for seedlings,
try and find runners, too, and
dig into the ground, gently, around
fresh shoots.

- Have a close look at a handful of soil.
Use a hand lens. Can you spot seeds?
Or bulbs? Or rhizomes with nodes? Or...

: Yes? How many?

: NO? Well, put a bowlful
of topsoil in some vessel.
Keep it moist and warm.

Cover it - or put it into - a
plastic bag and look what
happens in a few days' time.



Go back to where this soil came from and look!

Mystery Seeds



Scrape fresh soil from under your shoes or boots after walking in the "fields" or in the countryside.



Or collect soil from a well-used doormat.



Sprinkle this on top of some soil in an old baking tin, or something. Moisten it and keep it moist and warm --- wait ---

and see what grows out of it patiently...

perhaps

Then go out and see if you can find the same plants and look what their seeds are like --- (if you can find any)



Problem?

How can you be sure, or make sure, that the seeds were in the soil that came from your shoes or doormat?



Yes, and not already in the soil in the old baking tin?

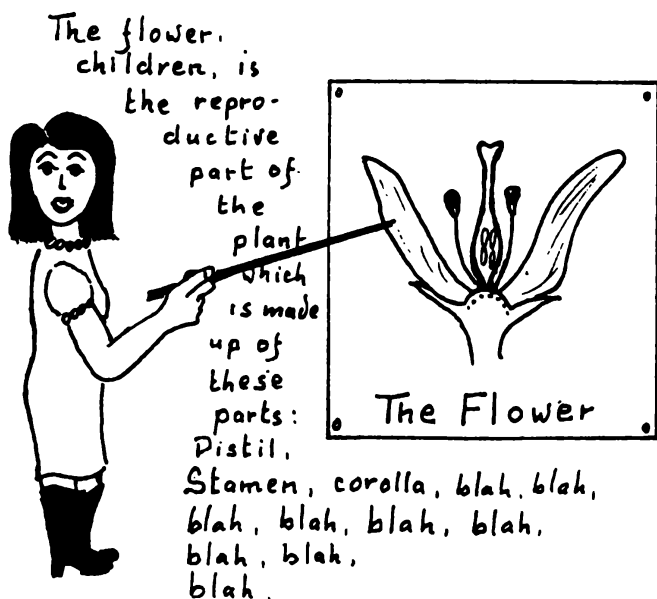
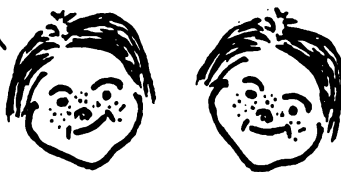


Oh, that is simple! Just heat the ---



sshhh... Let the children talk about it first, and try to find a way out of this problem.

What is a blossom? What is a bloom?



This language lesson may be useful, but...

Does "The Flower" exist?

Go and find it in the garden.

Collect a variety of flowers and blossoms. Try and identify those parts in each bloom which seem to have the same function.

Divide a paper so that you can stick or tape or sketch parts of flowers which "belong" together.

Petals	Sepals	Pistil	Stamen	Ovary

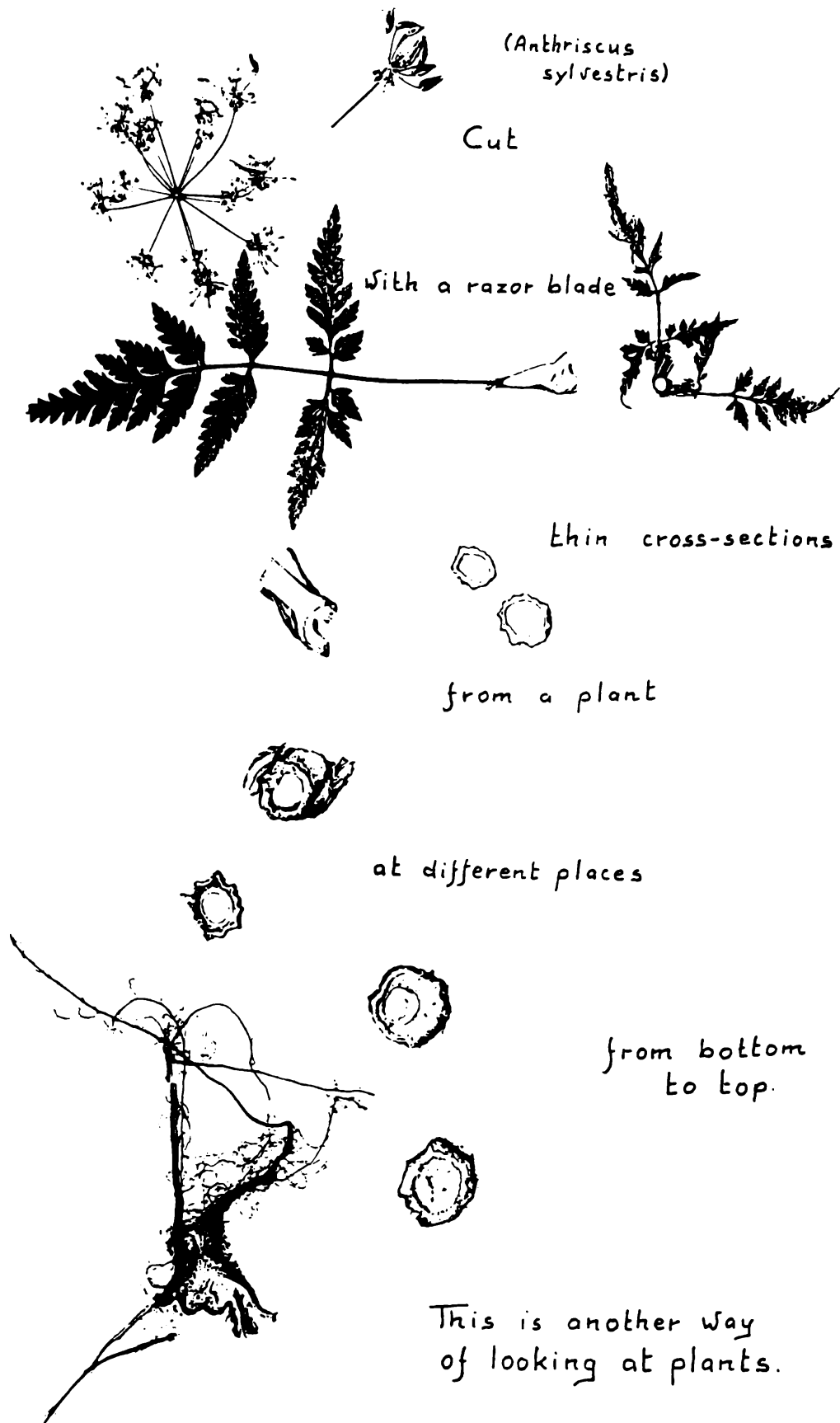
Help the children with proper terms when needed. Use pins, (a razor) and handlenses: tiny flowers are flowers, too.



My mother says her geraniums are good bloomers

Oh, but my Granny wears them.





Classifying Plants.

Please.

bear in mind
that this is a
look-and-think
exercise. The
final result is not
the most important



Children should talk
and discuss and argue
about their divisions,
for their choice should
be based upon the answers
to the questions:
Why this choice of division?
What do the plants in one
group have in common?

A brief description
characterizing each
group can be written
on a small piece of
paper, or a card,
which then can serve
as a label to each
group of plants.

See following page.

For this you need quite
a few plants...

Before local frontgardens
get ruined or the floral
environment becomes de-
populated, look for a
convenient piece of ground
where many common plants
occur.

Let children form groups
of five. Each child is to
collect five different plants,
including grasses. This
results in each group
working with 25 plants,
which is enough.

- ① Divide all plants in two
groups.
 - Why do you do it this way?
 - What do the plants in one
group have in common?
 - Does this exclude the opposite
group?
- Briefly describe and
characterize each group.

② Divide the (two) groups
again into two groups

③ Then once more divide
the 4 groups into two..

④ and again...

⑤ and again...

until you cannot divide
a group any more, because
there is only one (kind
of) plant left in it.



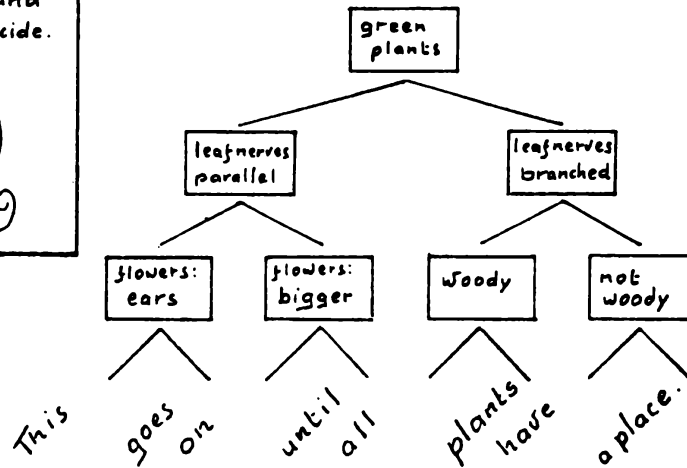
I did it
my way.

Key

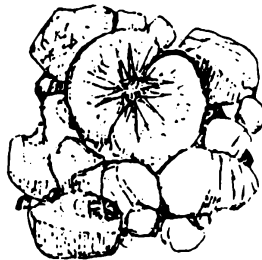
It will be rather difficult for the children in the beginning to spot exclusive characteristics. Talk with them, argue with them, and help them decide.



If the children manage to divide and subdivide their collection into yes/no groups, and to label each group accordingly, they may get something like the following pattern:



Having done all this "properly" you should have a simple key by which to "identify" the plants in your collection.



Plant?
Stone?

In the same way you can compose a key to "identify" : autumn leaves
: stones, shells, coins.
: or even the children in the class.



It is worth trying!



Minibeasts and Environment

"Environment" is a very difficult concept, and children only begin to form it.

They need lots of time and plenty of "supporting" experience. Do not attempt to "explain" it in words.



Environment has so much to do with the interaction between living organisms and everything around them, in their immediate surroundings:

- the soil
- the moisture
- the humidity
- the temperature
- the air and the wind
- the weather
- climate
- season
- clouds
- rain
- sunshine

But how can children learn this very complex matter?



- the position of the land and of the (ground) water.
- the prevailing physical features
- the geology
- and all other things living or dead.



Go to the ant, thou sluggard, consider her ways, and be wise.

Indeed, whenever children work with minibeasts, they should work with their minibeasts' environment as well:

- Where does it live?
- What is it like there?
 - is it dark there, or light?
 - cool or warm?
 - moist or dry?



- Does this minibeast walk?
 - or fly?
 - or creep, or crawl, or slither?
- Where does it sit down or perch? How?
- Does it dig? Bore? Spin? Build?
- Have you seen it eat? What? How?
- Does it live there where you saw it?
- Does it grow up there?

If you want to keep a minibeast.... can you make a good home for it?

Some more Minibeast-in-environment Questions.

Do the same kinds of minibeasts live and thrive in different places? For instance: flowerbeds, railway embankments, farmland, lawn, road verge, hedgerow, garden, hill top, down, dale, ditch, wood, brook, pool, pond, meadow?

- Or is there something in different places which is the same?

- Or, what is particular to different places where

a) the same minibeasts live?

b) different minibeasts live?

How wet is wet?

How warm is warm?

How light is light?

How do you measure all this?

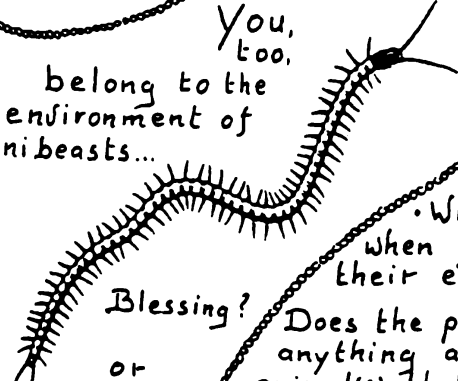
Is it moist or dry? Watery?

light or dark? Warm? cool?

Overgrown? Open?

Screened? Bare?

You, too, belong to the environment of minibeasts...



Blessing?

or

Doom?

What do they do if and when you yourself change their environment?

Does the place tell you anything about the (small) animal(s) that live(s) there?

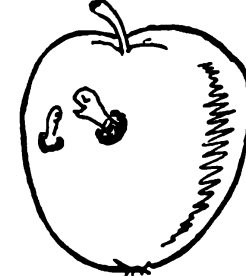
Does the animal (its structure) tell you anything about its natural environment?

Observing any minibeast: What characteristics make it suited to the place where it lives? What characteristics of the place make it a suitable environment for particular minibeasts?

Do little beasts, that live in a similar (or in the same) environment, have anything in common? Colour? Shape? Eyes? Skin? Breathing organs? Legs?

Do little animals change if their environment changes? How?

"Our environment is well suited, hey mama?"

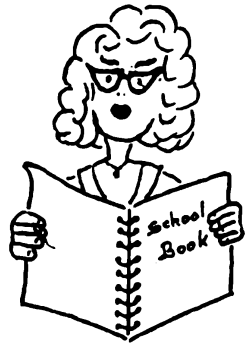


"Yes, dear, but the Club of Rome warns us not to use it up!"

Do they live solitary? In pairs? In groups? Or in multitudes? Who eats whom?

Nota Bene:

Observations made by children
are always valuable,
but their "interpretations"
need a little caution...
and so do your own...
and certainly those of schoolbooks.



Conclusions on (e.g.) animal
behaviour, or form and function
relationship, are easily jumped at,
or just taken for granted.

The "why" and the "how" of animal
behaviour can often be related
to the environment in which
they live, but no more. Nothing
is self-evident.

Nevertheless, children should talk about their
observations and discuss about possible
interpretations, but then in the sphere
of "I think that...", "Could it be that...": to
hypothesize is fine, because it leads to:
"Shall we try and verify what we think?"



"Help the children to base
their "explanations" and
"interpretations" always
on their own observations."

"And enhance these observations
by asking answerable questions"



Why does that
caterpillar have
bristles?



This is
a good example of
a bad question.
It is not answerable.
For a good question:
Use DO-or LOOK-words:

What does the caterpillar do
with its bristles?
Are they soft or hard?

And what to think of:

Why has a centipede a
hundred feet?

Write a better
centipede question
below:



Children, mirrors and reflections

Introduction

Mirrors are fascinating things to play with as well as to work with, for they hold an element of magic. Magic and science seem to be at odds, but not necessarily to children. An exploration into the reversed double-world behind the looking glass may well retain something of the thrill of the fairy tale and so provide a strong motivation to pursue some real science. The fairy-tale mirror does not exist in the real world. Every child knows that. But the mirror does and so does a child's wonder about its workings. It doubles whatever is in front of it; it shows you your own face; it makes letters look funny and, at first, illegible; left and right seem confused; it bounces sunlight into a bright spot on the wall; and in combination with another mirror it seems to keep on reflecting reflections infinitely.

Mirrors are universally available and cheap to purchase; children can easily be induced to borrow a mirror from home. Any piece of glass, especially when blackened on one side, makes a workable, though not ideal, mirror. Any shiny, smooth surface can serve as a mirror. In fact, the shape and form of some ordinary shiny things, such as teapots, wheel-hubs, reflectors, Christmas decorations or spoons add to the challenge, for they make things look different.

The activities in this chapter need little introduction to the children: just provide them with mirrors, and slowly structure and order their investigations. It is a unit of learning which entirely depends on the children handling mirrors and other things they need. By direct experience and experimentation children will extract information from the mirrors.

It does not take long for children to start exploring when mirrors are placed in their hands. A certain amount of free exploration, as a 'getting-to-know-you' exercise, is essential. It focuses the children's minds on an area of

science; it generates initial questions; it opens a perspective to 'what you would like to know' and . . . they do it anyway. However, free all-over-the-place messing about is still somewhat removed from the scientific inquiry which the children have to learn. The teacher is the one who should bring order and system in the children's explorations and turn them into genuine investigation. Having noticed the children's interest and the direction in which it seems to go, the teacher intervenes. Sometimes the work is stopped altogether and the class discusses possible lines of investigation which have opened up. Sometimes the children are involved enough to be given, individually or in a small working group, a challenge in the form of a problem or a new piece of equipment. Questions and tasks may be given by word of mouth or by an appropriate worksheet. In all cases the work of the children is given more structure, direction and system; it is ready to become more scientific.

This chapter presents a number of ideas for children to investigate various properties of mirrors and how they interact with light. A number of pages (particularly pages 236 to 242) could be copied as they are and given to the children as worksheets. They suggest some problems and indicate how, with the help of one or more mirrors, solutions can be sought. Many of the ideas and tips given on other pages can be transferred to home-made worksheets.

Any unit for children is a teacher's resource. Many ideas and suggestions are given, but they still need the creative teacher to turn them into children's activities or investigations at the right time. Even ready-made worksheets still need the judgement of the teacher as to where and when they should be employed and whether they should, or should not, be adjusted or extended. Worksheets are there to facilitate the work of the teacher; they are aids, tools for the teacher who retains responsibility for ensuring effective learning through the activities. The 'Figure Cards' and 'Sample Cards' described on pages 244 and 245 need to be made by the teacher, after which they can be given to the children to solve the problems they pose. Making sets of these cards is, of course, a very good teacher-training activity. The technical problems of making sets of these cards is slight. Those who cannot draw can use very simple figures, make a stencil or use small stickers. There are so many ways to make this easy that it should put nobody off. Apart from the work of composing pictures-to-be-matched, one is compelled to think. Perhaps there should be 'easy' sets as well as 'tough' sets; what makes a scale of difficulty from simple to hard? Would you include a few cards with an 'impossible' problem (such as the example of a card on the left of page 245)? It would not be bad for the children to realize that in the world of mirrors there are things that just do not work. Mirrors with all their 'magic' obey strict physical laws. A few impossible figure or sample cards may start a lively discussion as well as provide an opportunity to review and summarize the children's findings and ideas so far.

There is no definite sequence in activities provided here. The teacher

should use his or her own judgement on what to start with, and on how and with what to continue. The teacher can add activities and inevitably the questions of the children will lead to things not included here. It will be helpful to have other sources and books at hand, and to use them as the occasion arises. Periscopes, lateral inversion and angles of incidence, among others, have been left out because they can be found in every school textbook.

It sounds rather ambitious to expect primary-school children to understand the physics of light and reflection, yet by way of encounter and interaction with mirrors it is entirely possible. Of course, 'reflection' means little or nothing to children unless it is there, present in the mirror they hold in their hand, changing when they change the position of that mirror, or multiplying when they move another mirror nearby. Accumulated experiences, encouraged or suggested by the teacher, ordered and reflected upon in discussion, formulated in words by recording, and given specific meaning as verification of some hypothesis, may order themselves into patterns of understanding; and ideas of a higher level of abstraction may evolve in the minds of the children. They may find that searching behind the looking glass need not be magic in order to be satisfying and rewarding.

CHILDREN,

MIRRORS

AND

RECEIVED
JAN 10 1891

JOS. ELSTGEEST

These worksheets are about doing with mirrors: about getting children to interact with mirrors. You will not find 'lessons about mirrors' in them. You will not even find any 'useful' information about mirrors. What you will find are a few starters to get children to investigate and solve problems with the help of mirrors.

Once the children are off on their investigations, be prepared for all sorts of questions. Don't let this alarm you, for either: (a) the mirror will provide the answer (and it is good to learn how to ask the mirror); or (b) you know the answer, which makes it easy (well . . . !); or (c) there are books available which provide an answer; or (d) the answer is simply not known by you nor by anybody. Well, let it be so.

Mankind is still learning, and we are not omniscient. That, too, is a very good lesson for our children. Periscopes, lateral inversion, angles of incidence and like bits of language and technology have been left out, for you can find these in every school textbook. So use these terms where appropriate and called for by the interest and questions of the children.

Mirrors and reflections



What shines
and mirrors
all around?

This is a good starting
question. Many surfaces
shine and reflect light,
some more, some less
than mirrors. All help
to understand how light
is reflected

Write down five
objects, seen from
where you sit, and
place them in order
of "reflectivity"



reflectivity?



Could you
make a list
of "mirror words"?

- mirror
- shine
- reflect
- radiate
- bounce
- glisten
- glow
- gleam
- glint
- polish
- sparkle
- image

Look
for things
which show
or do what
these words describe.



Examine these objects and
try to find words which
further explain their
reflective qualities, such as:

smooth	glassy
polished	level
burnished	flat
waxed	unruffled
varnished	bald

- clean
shave?



This helps children to
develop an eye for
(relevant) physical
properties of things.

Besides... it helps them
to discuss sensibly about
their observations.

Sit around with your children and discuss all together your experiences and observations; raise questions, suggest possible answers, propose experiments and agree on what to do, on who does what, on how to go about it and how it all should be recorded and communicated.



How do things become like mirrors?



Boy! Glass mirrors perfectly! Just look at it from an angle.



Ripples in the water make it a funny mirror. You get a rippface in it



Spoons and tea-pots and water-kettles are fine mirrors, like my specs!

And my eyes!



Kitchen foil reflects, but it does not mirror

So do my shoes, provided I have polished them!



Little shiny round things like buttons make things look ever so tiny.



An aquarium is a fine mirror. Look at the surface from below. Everything swims upside down!



Mirror ?? ɹoɹɹiM



What makes
a mirror
a mirror?

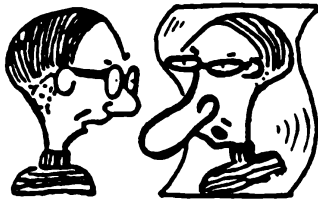
Oh, but then
we need lots
of mirrors
to do things with!



Why don't you
ask the mirror
itself?

↑ That is the way to ask the mirror, so see to it
that there are sufficient mirrors available:

Ask the
mirror
what?



- a) Bring some yourself
- b) Ask the children to borrow
all sorts of mirrors from
home: small ones, big ones;
mirrors that enlarge or
diminish; rear-view mirrors;
spoons, coffeepot lids, buttons,
christmas decorations, copperplate,
buckles, bumpers, as long as it
mirrors.
- c) Let the children work in groups
so they can work with each
other's mirrors, and share
ideas and experiences.

Questioning, doing, trying,
figuring out and renewed
questioning will follow naturally.

What follows consists of tips, ideas,
suggestions, gentle nudges...

- Some pages may be (photo)copied
as worksheets for the children.

Remember: these are only starters!
Add and change whatever you want:
you and your children are the boss!

Children can do a lot with mirrors

Just give them mirrors
... and watch

ɹɹɹɹ
10111M
9d3 no
...llaw



Who?
me?

In the mirror... you can look at yourself (or others).
you can look round a corner.
you can look in your mouth

With two
mirrors
you can
look behind
your ears.



If you hold the mirror above
your eyes or your head:

- 1: everything looks upside down,
- 2: and in this upside-down world
 - you can walk and jump,
 - shake hands,
 - walk a slalom through a line of chairs or stools,
 - place something in a matchbox
 - and put it on a table.

- 3: You can try and follow a snaky line on the ground.
Draw the line or use a rope or a garden hose.

Rules:

- never step on it,
- keep it between your legs,
- never look at it,
- unless through the mirror.

- 4: How long can you stand on one leg in your topsy-turvy world?





Try and walk through the school building (and out of it by the frontdoor) holding a mirror under your chin: look into the mirror held steady, and facing upward.



Can you make a full face out of a half?

31bd 070
70 300 9007
9900 11070



Try this:

- Place something small between two mirrors held upright at an angle
- Count the images and measure the angle

Change the angle and count the images again

Note what you get

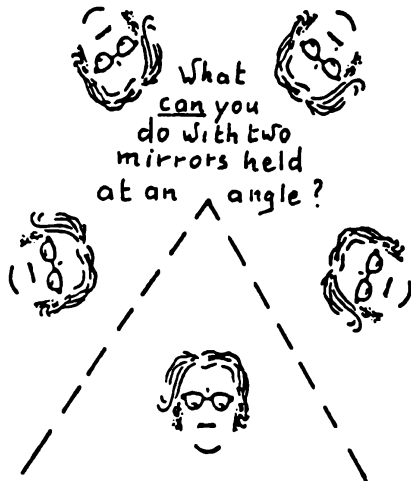
at 180°:	-----	images
90°:	-----	"
60°:	-----	"
45°:	-----	"
30°:	-----	"

Make this into a simple graph: x angle
y no. of images

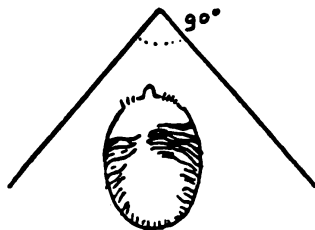
Can you now figure out a formula which gives you the number of images for any angle?

With two mirrors you can ...

Well,



Look at yourself in this 90° combination...



then wink at yourself.

Can you explain this?

WRITE

your name
in mirrorscript

(that is: so that you can
read it in the mirror.)

ni dloKleffers 249t9/k

IN CAPITALS

mirrorscript

I know a trick
Turn this page
over and hold it
up against the
light



You are allowed to
use tricks, but do
try it without tricks
first.

You may write
"mirrorwords" anywhere:
on paper,
on the floor, the ground,
on the blackboard.

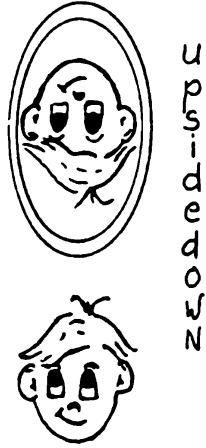
Which letters of the alphabet
do not change in the mirror?

--	--	--	--	--	--	--	--	--	--	--	--	--

Can you write whole words
which do not change in the
mirror?

... Or a sentence ...

Mirrorsc



B C D

A M

T W

I O

V X

H Y

U



DICK BOXED BEDE

**M
A
M
A
I
A
M
H
O
T**

Copy this sheet for the children.

Glue the letters on thin cardboard,
and cut them out.

Now you can make mirror-scrabble
words.

Could you invent a mirror-scrabble-game?

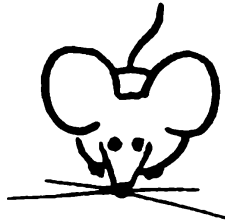
Make up your own rules.

B	B	B	B	C	C	C	C
D	D	D	D	E	E	E	E
H	H	H	H	I	I	I	I
K	K	K	K	O	O	O	O
A	A	A	A	M	M	M	M
T	T	T	T	U	U	U	U
V	V	V	V	W	W	W	W
X	X	X	Y	Y	Y	,	,



How many mice
can you make with

- one mirror ?
- two mirrors ?
- three mirrors ?
- more mirrors ?



What difference(s)
do you see
when you "multiply"
the first or
the second mouse?

Draw or describe

- a) the position
of the mirrors,
- b) how the mice are
sitting.



What more
can you do
and find out
with mice and mirrors?

And what do you get

- when you mirror
tiny mice ?
- or a picture of yourself ?
- or a pencil ?
- or ...
- or ...

you can take anything.



Even with the word

"mouse" you can
make something nice
using two (or more)
mirrors.

Try it and draw
the result.

MOUSE

Draw what you can make
out of each of these
figures and a mirror:

L

S

LYBBERWOCKY

And the mome lath onslape.
All mimsy were the poroloxes,
Did gyre and gimble in the wabe:
"Twas brillig, and the slithy toves

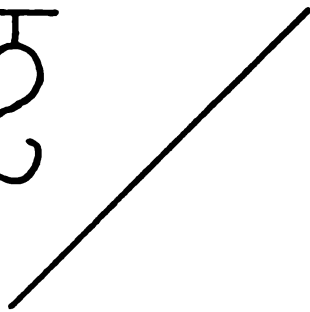
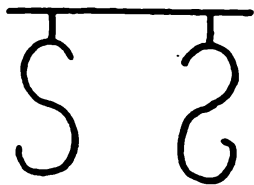
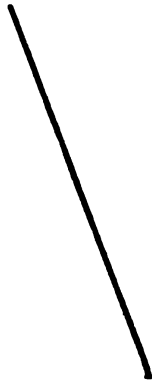
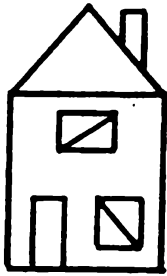
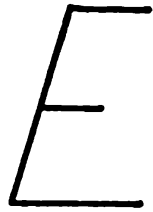
Lewis Carroll

WUWELWOK

Bei 't plinzen der perien.
Hoe klom woren de ooljant,
Bedroorden zjandig in het zwien:
't Was prodig, en de spiraumont

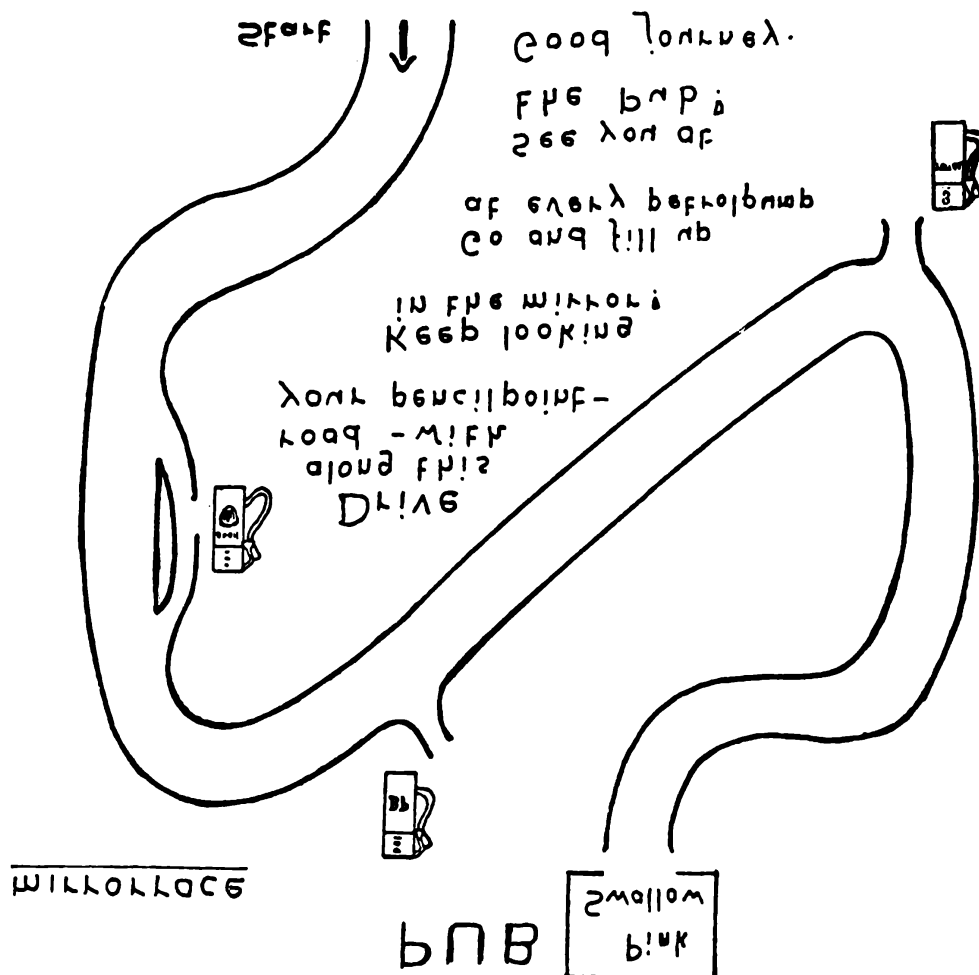
Draw the figures (left)
as you will see them
when you place a
mirror on the line.

Only after drawing can you check with
your mirror and see how correct you are.



Take a sizeable mirror
and hold it firmly above
your eyes, or high in front,
so that you, looking in the
mirror, look down upon
this paper.

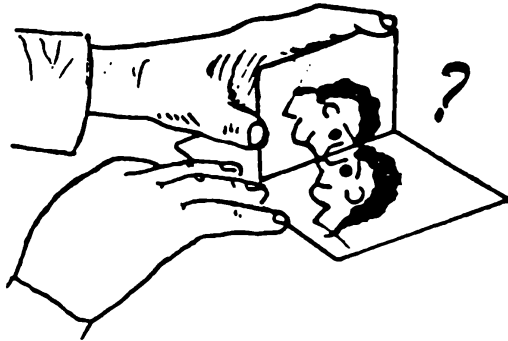
Then follow the instructions underneath.



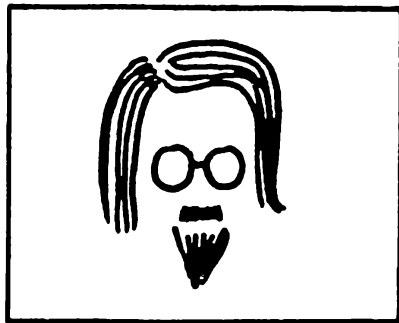
Mirror-work and problem cards

With any picture
and any mirror
you can make many
pictures.

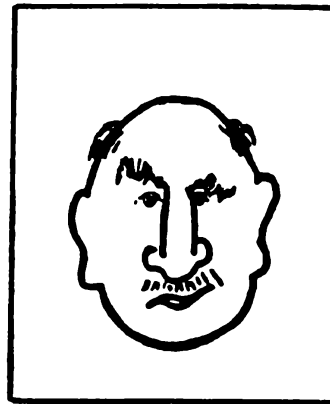
- ① Paste faces, houses,
trees, landscapes,
on thin cardboard
and see what it
becomes when you
slide a mirror
across it in any
direction...



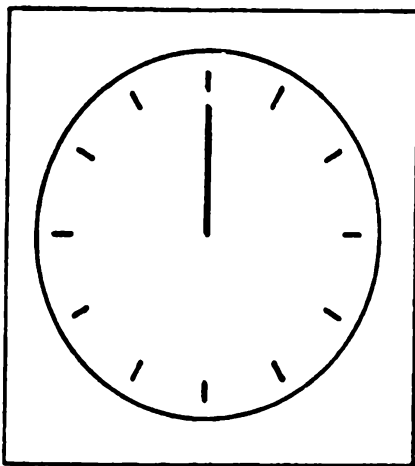
... just for fun...



...or to challenge
one another.



- ② A real problem card:



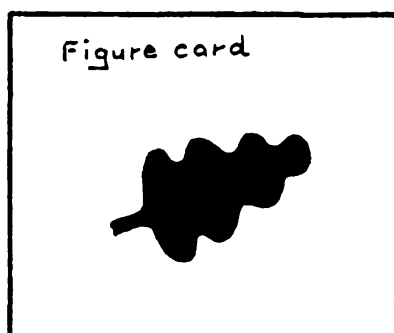
Use a mirror
and this clock
to make:

- a) Breakfast time.
- b) School time.
- c) Dinner time.
- d) Bed time.
- e) Free time.
- f) No time.

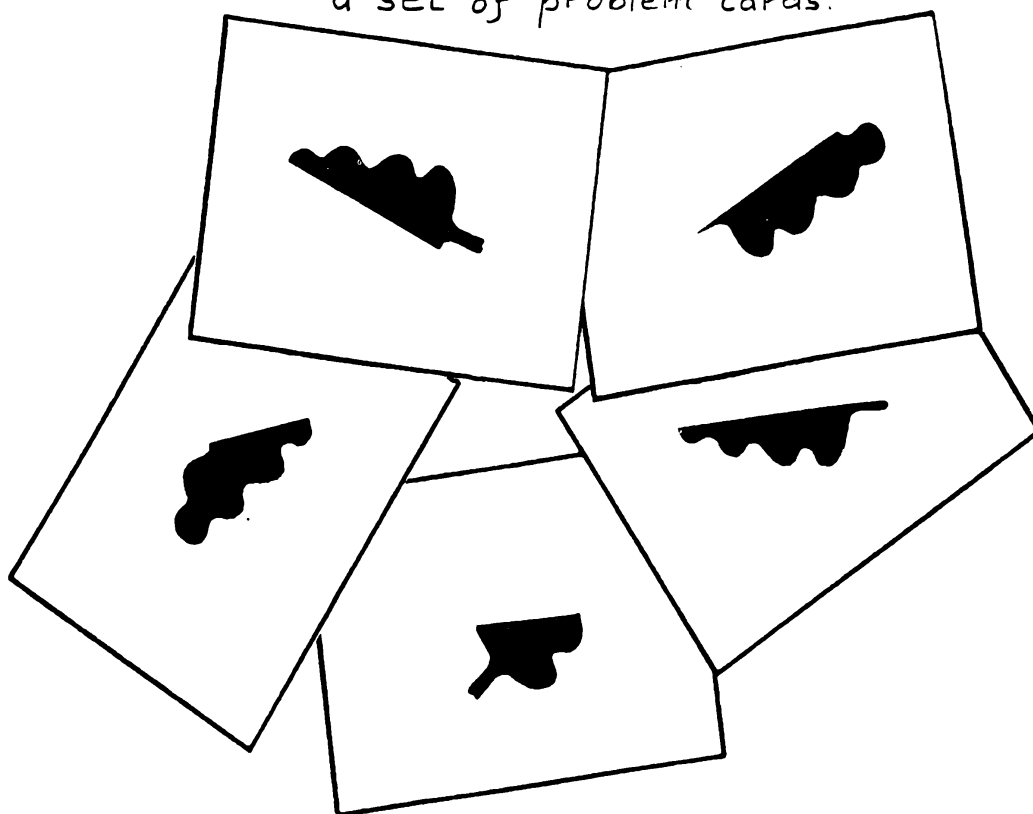
or any time

③ Figure Cards

You need one "figure card":



and
a set of problem cards.

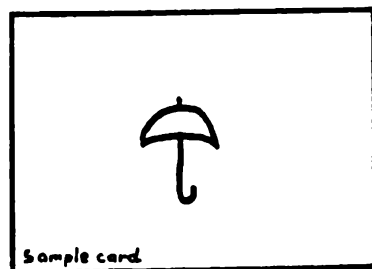


The problem is: with which of these cards
-and a mirror- can you
reproduce the figure
on the figure card?

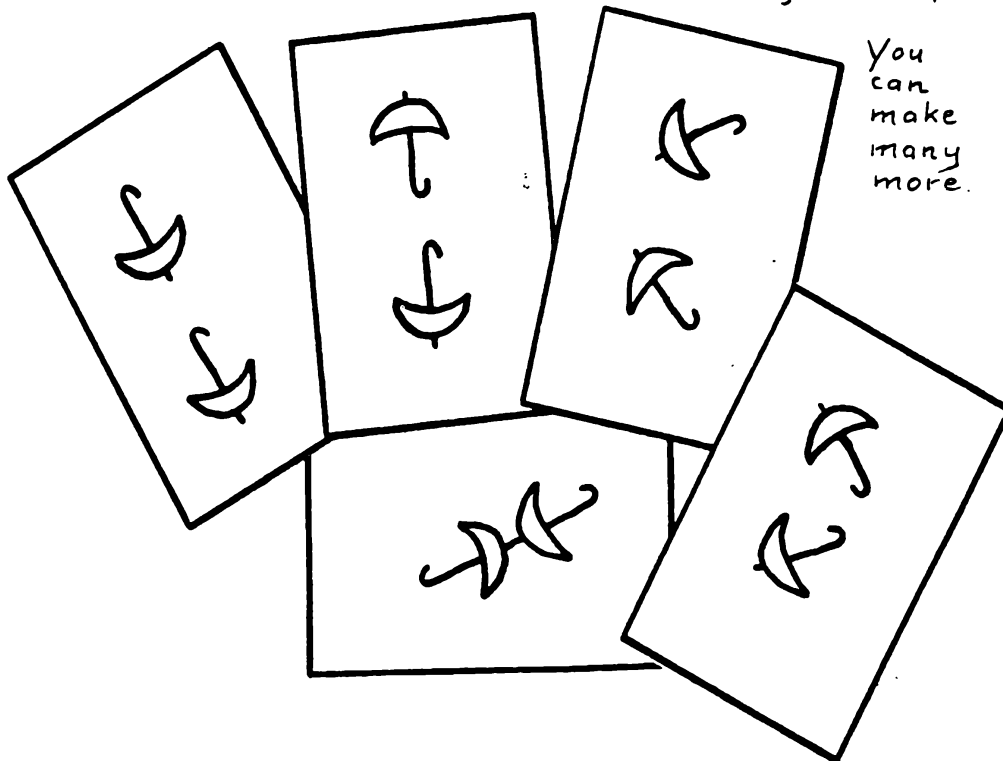
④ Sample card problems

This is another set of problem cards whereby a mirror is used with the "sample card" only.

The problem is: try and copy the configurations found on the other cards. (Can you, or can you not?)



N.B.
These are only
a few examples.



You
can
make
many
more.

Make various such sets.



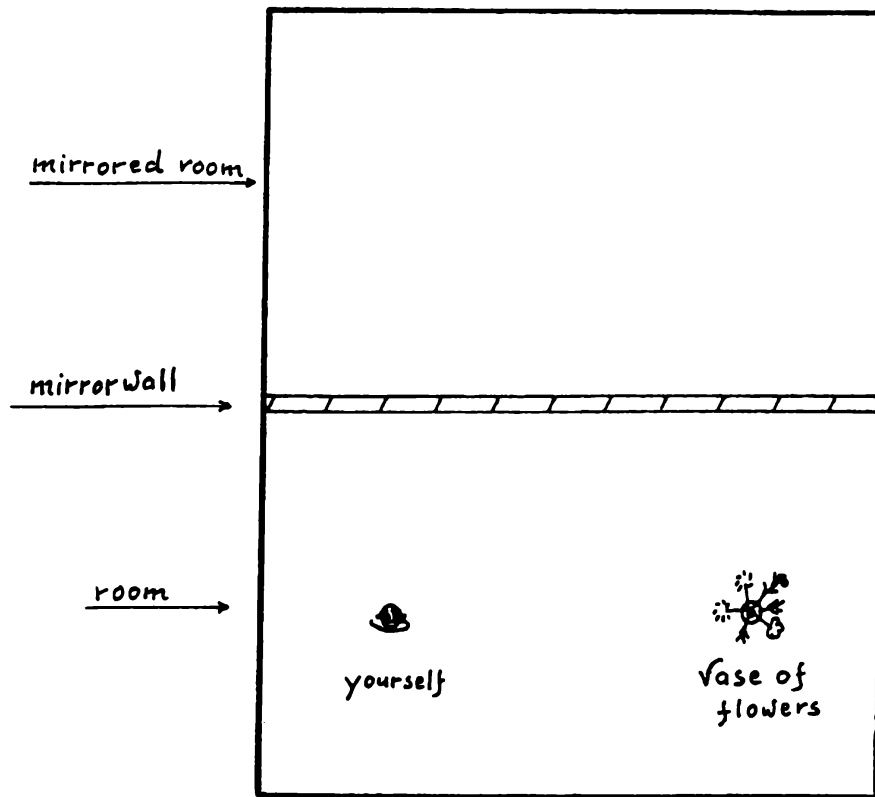
Perhaps a
nice project
for helpful
parents..?



famous
last
words!

The Problem of the Mirrorwall

Imagine you are in a room
one wall of which is one huge
mirror. You are in the company
of a solitary vase of flowers.



You stand at the spot indicated
on this plan and you are looking
in the mirror at the vase of flowers.

Sketch in pencil the direction
in which you are looking



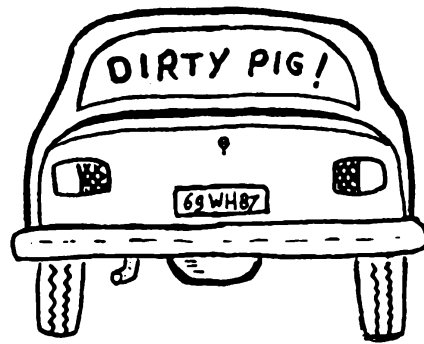
After drawing your "line
of vision", by all means,
do check with a mirror.
... But do not get
confused.

The Problem of the Rear-view Mirror.

Shine or tempest, my car is parked outside.

I had not washed it for quite some time...too long,
and so it happened that my rear window looked
somewhat grimy...

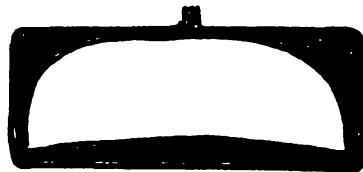
A naughty little neighbour-boy scribbled on it
with a wet finger:



At first I did not notice anything
until I boarded my vehicle and looked
into my rear-view mirror...

What exactly did I see?

Fill into this
mirror image
of my rear window
what I actually
did see.



← rear-view
mirror
with
mirror image
of rear-
window.

Please, how do you explain this?

The Flexible Mirror

Flexible sheets of thin shiny metal or plasticized foil make beautiful flexible mirrors, but these are not easy to obtain.

A sheet of acetate - overhead projector transparency - fixed onto a dark, black, paper makes a very good substitute.

Position yourself facing a source of light (a lamp or a window) and having a darker, shadowy, background, and look at yourself in the flexible mirror.

What do you see,
if you flex it---

like this..



?

or

this..



?

or

this..



?

or

this..



?

or

this..



?

or

this..



?



brush up
your
image!

-Place a newspaper headline in front of
your flex-mirror

What do you see?

And what do you see
if you flex the mirror?



convex



concave



Draw here



Talking about your work and experiences is very important.

Allow children,
as a matter of course,
to muse and share
ideas and problems.



Children and balances

Introduction

Balances are good learning aids in science education and therefore good teaching aids as well. They can be simply made so that children can work with them freely in the classroom. They give children access to some sound science. Not only do children gather some valuable information (so-called 'science facts') in the form of fundamental principles of mechanics (the interplay between forces and movement), they also practise scientific process skills which can lead them beyond these few 'facts' into self-reliant learning and independent thinking.

The title of this chapter has been chosen with a **purpose**. Children manipulate a balance in order to learn about some of the laws which govern its workings. The condition for learning and understanding is that the children are fully involved: by seeing for themselves, by doing things themselves, by thinking themselves, by verifying things themselves, by making mistakes themselves and by reconsidering their ideas themselves in the light of evidence which they have uncovered themselves.

The children are therefore not given answers before they have had a chance to ask questions. They are confronted with materials that contain a challenge, that raise questions or problems, and that have possible answers within them to be released by thoughtful interaction. The children ask the balances; the balances provide the answers. The teacher helps in the asking as well as in the effort of finding an answer.

The aims of this chapter are to help teachers help children to use balances as a source of information; to 'ask the balance', using scientific process skills; and to generate, through using scientific process skills, the kind of knowledge which leads to further knowledge.

How do children use balances as a source of information?

The balance does something in response to something done to it. This makes children's observations of the working of a balance *active* and *selective*. Pushing it down and then letting it go; adding a weight to one side; removing a weight from another side; piling up weights on either side; matching weights to balance; and matching different objects to balance. All these simple actions provide active experiences which leave behind (bits of) ideas on how the balance works.

The first few pages of the chapter suggest that the children do just that. The children's active learning with balances involves thought-processes which are expressed, quite spontaneously, by the children talking. The teacher should, with open ears, make use of this by joining in the talk, either by talking with a child individually or by leading a group discussion about what the children did and what they noticed happening. The active building-up of ideas and concepts while working, together with the co-ordinating exercise of talking about it and discussing findings, soon leads the children to make more general statements on recurring events. Pages 259, 260, and particularly 261, provide examples of this.

It will be found, however, that younger children need much practice before they come up with (or accept) a general abstract statement, such as 'the same volumes of the same substance balance' or 'if A balances B and A balances C, then B balances C also'. Such abstractions may be clear to teachers, but children will tend to try out every instance. We should let them, for this is the way in which they form, test and use patterns.

How do children 'ask the balance'? How do they learn to apply and practise scientific process skills?

If the children just play about with balances without, somewhere along the line, being given some order and direction, they will probably make some interesting discoveries, but learn little science. It is the teacher's task to introduce some order, or some system, into the children's work, by helping them to make the appropriate next step forward when they come to it. The discussions among the children themselves and, more so, the discussions with their teacher, provide ample opportunity to ask the right question at the right time, or to make a suggestion for further activity in order to find more or better answers from the balance. Questions which the children ask themselves or which they adopt from their teacher are an inducement to learning and a strong motive to make an effort, to investigate, to take care to be accurate and not to give up before some understanding has been acquired.

The scientific process skills which the balances invite the children to practise are accurate observation, classifying objects, calculating, comparing quantities, manipulating materials (and instruments) deftly, some designing and making, finding patterns and relationships and, above all, the raising of motivating questions.

The use of these skills, made more conscious by discussion, brings order and purpose in the actions the children undertake. Creating this order and discipline in handling things, creates order in the concepts, ideas and thought-processes which generate from these experiences. For examples one can turn to pages 261 to 264, while the point is underlined by the true story on page 265. The last six pages, of course, should be considered, too.

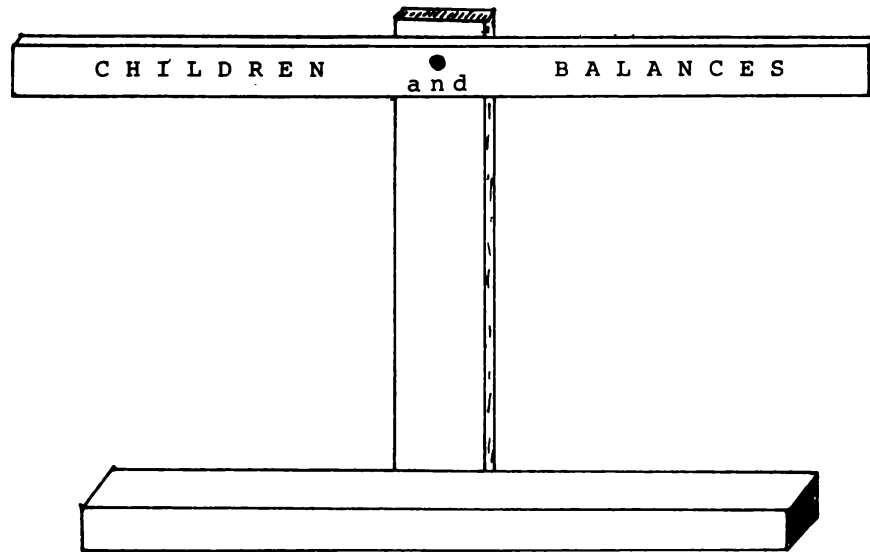
How does the practice of scientific process skills lead to a kind of knowledge which generates further knowledge?

The more elaborate exercise round the question 'What makes the balance balance?', which is suggested on pages 266 to 270, has proven to be a powerful illustration of how science – via accurate observations and careful recording – can lead to a short-cut towards learning. After having defined, on page 266, some unit of weight or mass (paper-clip) and a unit of distance from the fulcrum (the distance between holes in a strip of pegboard), there are a dozen or so definite simple problems to solve with the help of the balance. Confirmation of the right solution is given by the balancing balance and the outcome is systematically recorded according to the suggested scheme and outline.

Invariably, someone somewhere along the activity will go beyond the simple trial-and-error approach and replace it by predicting what to do; a simple calculation is made and verified. In fact the formula 'Weight times distance on the left equals weight times distance on the right' (or any more sophisticated formulation of the law of moments) is being applied long before students are able to put it accurately into words. Soon a discussion develops around the question: 'What makes a balance balance? What is in equilibrium? The units of weight or mass on either side?' 'No.' 'Or has it to do with their position in relation to the fulcrum?' 'Yes and no.' Soon the proper relationship is worked out and can be expressed in words. At first the students may formulate this relationship in a rather roundabout way, but they will be able to exemplify it by using the numbers they filled in on their record. This shortens it, and from here it is only a small step towards a simple formula which corresponds with the words as well as with the figures $\Sigma(M \times D) = \Sigma(M \times D)$. (Which means that the sum of the units of mass times their distance from the fulcrum on the left arm equals the sum of the units of mass times their distance from the fulcrum on the right arm.)

Provided students, or older children, have had sufficient experience and have made clear records, they can either come up themselves with, or understandingly accept, this formula or its descriptive summary. It is precisely this knowledge which generates new knowledge: new problems can now be solved. The formula allows a short-cut. When an unknown element is then introduced, it can be worked out by simple experimentation and calculation, as the exercises suggested on page 271 indicate.

When the activities are carried out by student teachers, there is a double benefit. They learn or revise some fundamental principles of the physics of balances, which gives them confidence. They also analyse the scientific processes they undergo or apply, which helps them appreciate the process-based teaching which they may be asked to use in their work with children.



Jos Elstgeest



A gentle word of caution in advance

A balance is an instrument to do something with.

Only by doing something with it can one investigate its working, and so begin to understand some of the laws which govern it.

Because it is an instrument for doing, it can be placed in the hands of children, and thus it will invite them to interact, that is to explore, to investigate, to experiment and so gain experience. For our primary-school children this is sufficient. Investigation turns their minds into the fertile ground in which later understanding and more correct formulation can flourish.

Therefore, do not force anything upon the children at first. There is nothing yet to be learned by heart, but there is much to be learned by experience. Somewhere along the line learning by heart becomes useful, perhaps, but then they will understand why, and submit to it gladly.

There are simple laws of mechanics (the interplay of forces and movement) which can be discovered by simple investigation and experimentation. By merely manipulating simple balances children discover elementary relationships and these are all they can handle. Our abstract patterns are often beyond them. Primary-school children can manipulate things that work: balances. They have difficulty in handling our generalizations. We must give them time and opportunity to form their own generalizations out of their own experiences.

We can help them on their way by letting them work with balances, freely exploring at first, but gradually with more direction and purpose. The satisfaction of the experiences and the budding conception of what makes the balance balance, guarantee a solid foundation as a basis for reliable understanding when later abstract thinking gives meaning and coherence to observations and experiences.

What follows is a number of ideas on how to work with children and balances. There are no 'lessons on weighing', nor is there a treatise on 'the Law of Moments'. You may add and substitute what you like, as long as it helps you to start a lively interaction between children and balances.

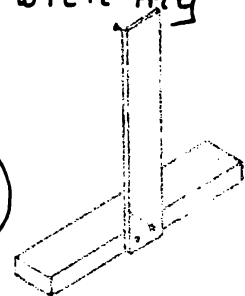
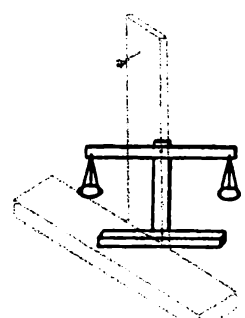
What is a balance?

What does it do?

How does it work?

How does my balance work?

How do I work with my balance?



equal? me a
equality?
equilibrium?



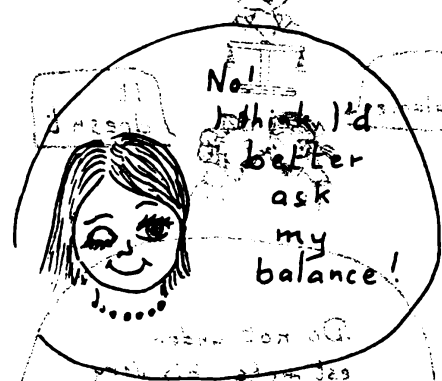
Shall I ask
my teacher?



a simple lever which
each of 5 N. There is only one
15 N to balance all the downward
will note that F_1 and F_2 are equally
for these conditions, the lever is in
from the center without shifting
is in equilibrium? The sub

on of the force
about an axis is generally
rotation is called negative.

In Fig. 11.40 the vector sum
ever is obviously zero. What is the
other point? Let us choose the right
to find the torques, or as it is
Torque of F_1 is $5 \times 0.70 = 3.5$
Torque of F_2 is $5 \times 0.30 = 1.5$
of F_3 is $5 \times 0.50 = 2.5$
is $1.5 \times 0.5 = 0.75$

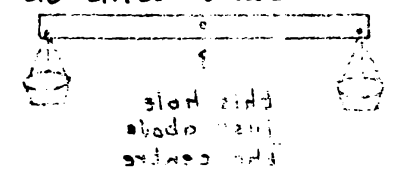


No!
I think I'd
better
ask
my
balance!

A balance is a
fascinating instru-
ment for children
to work with.

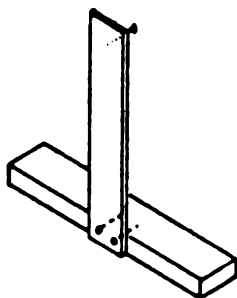
It "does" something
in response to what
you do to it. Your
self.

It does what I want provided
I know what it can do and what it
is that I want!

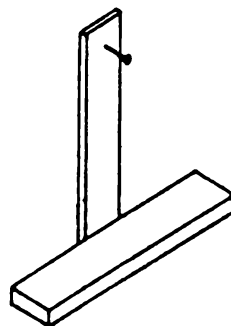


Would you like to Ask the Balance?

Then first make a balance.



- Use a
- small piece of wood,
 - a small slat
 - a hammer and
 - some nails.



These drawings show how to fix things.



See that there are enough balances: at least one between two children. Working in threes is also good: it enlivens discussion.



Add a strip of peg-board, two rows wide, and with an odd number of holes in each row.

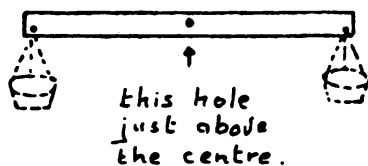
It balances



Look then!

It doesn't

But a thin strip of wood (a slat) with a few holes makes a good balance arm, too



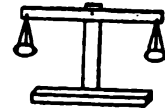
Do not underestimate this very simple instrument: it is sensitive to small fractions of a gramme



With the younger children

there is little to fuss about.

Make sure that there
are some balances
freely available ... together with
blocks, acorns,
beans, washers,
and assorted odds and ends.



Let them explore as they wish:
this is a first "encounter",
leading to a first dialogue: "What are you?"
"What can you do?"
"What do you do?"

These basic questions
are sufficient for them.
Watch and learn from children
and balances alike.



Miss!
It goes down!

Look! It
sits
crooked.



It tilts
when I
take
something
off.



First it
seesaws
and then
it sits still.

Short story.

Yulitha and Dominic are together working on the same little balance. Yulitha notices that the heavier side of the balance moves down. She adds a weight to the other side which now moves down. Soon she is satisfied with this observation and changes to something else. Dominic, however, notices that some weights cause the arm to dip only a little way, while other weights make it swing all the way down. This fascinates him and he continues to explore this further by trying out a multitude of different objects.

This shows that not all children do the same thing when they are working on the same thing.

Making Equilibrium



"With nothing on it,
it sits straight.
I can make it sit
straight with
beans, can't I?"

"Sitting straight."
we call:
being in
equilibrium.



"Making equilibrium now becomes
the end of the children's endeavours.
They like practising this skill by making
all sorts of things balance each other."



"Two chestnuts are
in equilibrium with
five acorns."

"Making equilibrium."
We just
call:
balancing.



"My bolt and nut
make equilibrium
with seven
washers."

Their trials are direct
and concrete, which helps
the children develop
objectivity in observation.

But "general rules" are not (yet) made, nor used.

"Let me see
what else would
balance
my bolt and nut?"



"Oh look, my
bolt and nut
balance
my rubber!"

"I shall try it."

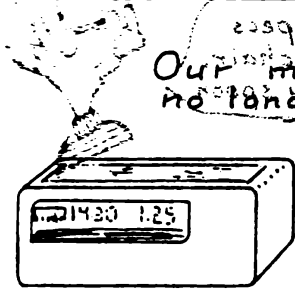


"Then,
of course
your rubber
also balances
seven washers."

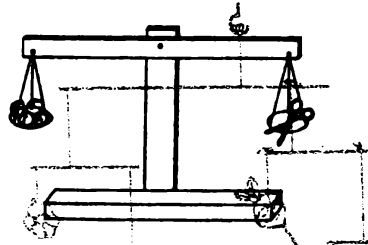
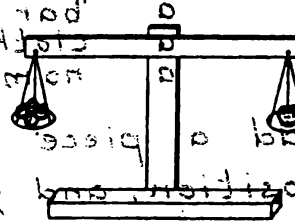
...but that is not so obvious
to this child!

What is not a balance?

From Balancing to Weighing.

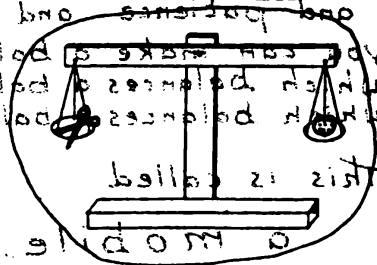


Our modern grocers no longer weigh their wares on proper balances. Instead they use some electronic gadget. Our children do not always associate weighing with



Four nuts also balance my scissors

Four nuts balance a bangerine



I think when two things are of equal weight they keep the balance always in equilibrium

Then the bangerine must also balance the scissors.

Sir, where are the weights?

Look for your own weights. These are fine units of weight they do.

This, at least, is true for the equal arm balance.

Once the children reach this stage they can start weighing things with their simple balances.

What is not a balance?

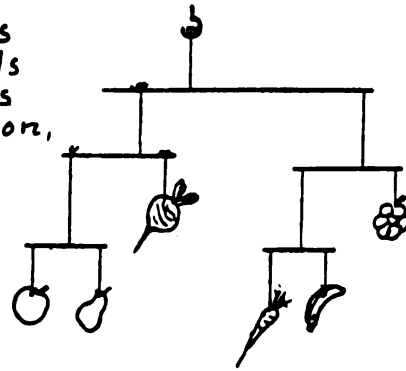
Take a twig,
a knife,
a board,
a stick,
a broom,
a shoe,
a ruler,
a straw,
a stiff wire,
a spoke,
a pencil,
a bar of chocolate,
a clotheshanger,
a no matter what;



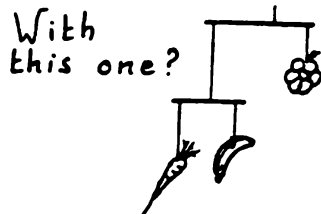
add a piece of string in the proper position, and you make it into a balance?

With sticks or straws
strings or threads
cut-outs or things
and patience and devotion,
you can make a balance
which balances a balance
which balances a balance!

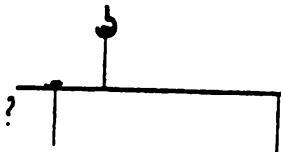
This is called
a mobile.



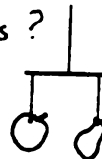
Try making it:
With which balance
would you start?



With this one?



or this?

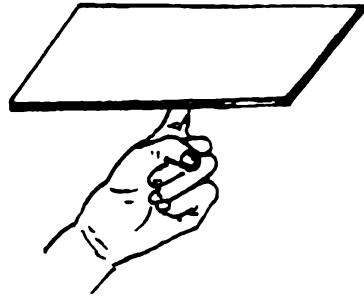


Children who can solve these little problems begin to understand quite a bit of the working of a balance.

So, why not let them do so?

Balancing Boards.

Can you balance a sheet of cardboard on the tip of your finger?

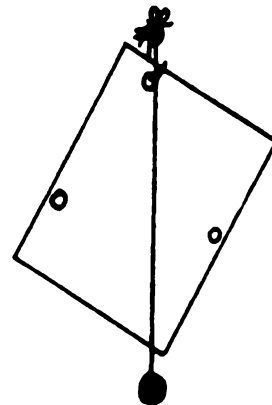


Try this:

- Make a simple plumb-line: attach a small weight to the end of a piece of thin string or a thread. Suspend this from a hook or nail in the wall.



- Punch 3 holes in your rectangular sheet of cardboard in three different places. (The 3rd hole is a control.)
- Unbend a paperclip into a hook. (Twist the bottom part forward by 90°)
- Hook on your cardboard and hang it behind the plumb-line on the wall.
- Carefully indicate how the plumb-line runs across the board.
- Repeat all this using the other two holes.



You can mark the vertical plumb-line by carefully placing two dots, just underneath the weighted string. By joining the dots with pencil and ruler, you draw a good straight line.

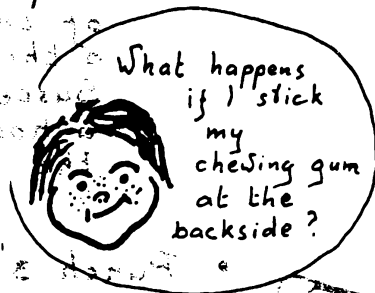
What do these plumb-lines tell you?

- What do they tell you about "equilibrium"?



Notice that the hole from which you suspend your cardboard is a fulcrum, a pivot, a turning-point... just like the centre hole of a balance...

- How would the areas on both sides of the plumb-line compare?
- Is it a matter of area?
- What is the importance of the point where the lines cross?
- From where to where do these lines run?
- Place the crossing point now on the tip of your finger...



What happens if I stick my chewing gum at the backside?



Can you balance it on the tip of your finger?

Note:

The point where the lines cross is called: Point of Gravity or Centre of Gravity.

Could you call it "Point of Equilibrium"?

Cut your card into an irregular shape. Repeat the plumb-line experiment.

Do the same questions apply?

Stick a weight somewhere on the edge.

Could you find the centre of gravity...

of a soup plate?

a shoe?

a knife?

a handkerchief?

or... your own?



I am nothing but a centre of gravity.

The children of a fifth grade at Vikundu, a village in the United Republic of Tanzania, worked with balances for quite some time. One of their activities was to compare various objects which they had found in and around their school, such as stones, blocks of wood, lumps of clay, dry bones, pieces of metal, fruit and inkpots. They started to arrange these things in order of weight. First they arranged them by feeling only, without using their balance. When they later checked their "feeling", they had to make some adjustments.



These children spoke Swahili, and they used the most common word, '*Uzito*' to describe literally 'heaviness'. The concepts of 'weight' as something measurable, or 'mass' as a physical property of substances, had not yet been considered or named. Yet the problem of 'heavy but small' as compared with 'light but big' did arise spontaneously, first as an observation, but soon as an object of wonder and amazement. The bolt and nut (inseparably rusted together) was small but much heavier than a big dry bone. It even beat a block of wood on the balance! How is this possible?

Although solving this problem was not forced upon them, it kept their minds busy. Because soon one little boy with a deep thinking furrow upon his brow declared that the 'heaviness' of the iron bolt and nut must be closely packed together, closer than the 'heaviness' of a bone or of wood. The bolt and nut of smaller dimension can therefore have more 'heaviness' than the bigger bone or block of wood.

Then the boy was allowed to explain his theory to the other children and they were asked to try to find some word or expression which would neatly describe this property. This was quite a linguistic proposition, but it set little wheels turning in their heads, and they came up with a surprisingly original term. They called it '*Uzito wa Asili*'. Literally translated this means 'heaviness of origin', the natural heaviness of things. What a beautiful example of trying to put an observation and its consequent concept sensibly into words! Would our "density" be so much better?



First of all: bring your
to equilibrium
the balance
gives you re
answers.

 = Right ;
  = Wrong =

These are examples
 of what to do and
 how to record it:
 Put 1 unit of Mass
 at Distance 14,
 on the left side,
and 1 unit of M.
 at D. 14 on the
 right-hand side.

Left		Right	
M	D	M	
1	14	1	
2	6	1	
2	4	1	
¹⁾ 1	14	2	
²⁾ 2	14	1	
³⁾	10		
1		3	
⁴⁾ 3		2	

This is one
 problem !

Mind: What has been written must be done; do that first. Then figure out what makes the balance balance... and fill in the blanks.



Left		Right	
M	D	M	D
5			
2			5
	9	2	14
	9		12
	7		2
	5		
2	3		
	13	1	9
3			
1			10
2		3	11
3	5		12

There are examples of what to do and how to record it. Get a unit of mass. It should be on the left side no more than 1 kg and no more than 1 kg. It should be on the right side.

End of unit. 4. 2. 1. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.

Now much is left to your own ingenuity; the recorded results may well differ one from the other, but if the balance is in equilibrium, the "answer" must be right. Do you agree?

Left		Right	
M	D	M	D
9) 3 	5 	 	13
10) 2 	11 	 2 	 11
11) 4 	 	 	15
12) 	 	 	



Do we have
to go the
long way?

No, let us take a short cut.

- Ask yourself:
- When is there equilibrium?
 - In what way does left equal right?
 - What is the meaning of $L = R$?
 - On what does equilibrium depend?
 - on the total units of mass?
 - on the distance(s) of the mass(es) from the fulcrum?
 - Or on both?

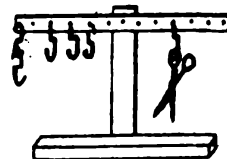
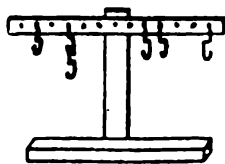
- If both M and D influence the state of equilibrium, how then are they related?

Can you express this in a simple formula?

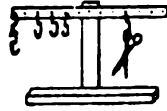
$=$



Do remember this well,
because with the help of this
formula and a balance you
can now solve many problems
that you could not solve
before.



Problem 1



Use the formula
to establish the
"weight" (or mass)
of these scissors.

(Use the paperclip as a unit of mass).

Problem 2

Find the "weight" (mass) of whatever
you find in your pocket:

- knife
- pen
- comb
- lipstick
- doesn't matter what

Problem 3

Find with the help of not
more than 4 paperclips (four!)
the exact mass of a ball of
clay (or plasticine)

Problem 4

What does a pin weigh?

Problem 5

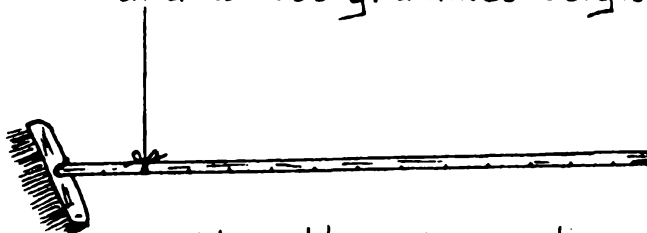
Establish the mass of your
balance arm ...



but without using
another balance.

Problem 6

You have a broom
a string
and a 100 grammes weight ...



Use this device to weigh
a kilo of sugar.

In many parts of the world, science education occupies a comparatively insignificant place in primary-school education and unfortunately what actually happens in the classroom under the label of science is often totally inadequate. Teacher training, both pre-service and in-service, is one of the keys to this problem. Starting from the premise that this training should be carried out in ways more closely related to the active methods which teachers are expected to use in their schools, this sourcebook provides a variety of materials for use in training workshops for primary-school teachers which can be used both in group-work and by individual teachers for independent study.

Dr. Wynne Harlen, OBE, is Director of the Scottish Council for Research in Education. She has broad experience of science teaching in schools and colleges of education. Formerly Professor of Education at the University of Liverpool, she has also held academic appointments at the Universities of Bristol, Reading and London. Dr Harlen is well-known in the United Kingdom and internationally for her work in primary-school science education, a field in which she has directed a number of important projects, particularly in relation to assessment of pupil achievement and teacher education. This has included close co-operation with UNESCO in the development of its programme in the field of primary-school science education.

Jos Elstgeest is Science Education Co-ordinator of the Regional Pedagogic Centre, Zeeland, in the Netherlands. Before this he worked at the Morogoro Teacher-Training Centre in the United Republic of Tanzania. He has been deeply involved with the African Primary Science Programme and the Science Education Programme for Africa. His work has involved close contact with UNESCO's programme in science education and he has served as a UNESCO expert at the University of Lesotho. He is particularly known internationally for his innovative approach to primary-school learning and the training of teachers.



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